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PROGRAM CHOICE AT THE UNIVERSITY OF ALBERTA OF STUDENTS WHO EXCEL IN HIGH SCHOOL PHYSICS

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled

Program Choice At The University of Alberta of Students Who Excel In High School Physics

submitted by Elidio L. Mascherin in partial fulfilment of the requirements for the degree of Master of Education.

DEDICATION

This endeavour is dedicated to Mr. Horace Allen, Principal (Retired), of Coleman, Alberta, whom I hold in highest regard as teacher, colleague and friend.

ABSTRACT

The purpose of this study is to determine what factors influence the choice of university program of the students who excel in high school physics.

Students selected for this study were high school matriculants enrolled at the University of Alberta. The criteria used for the selection was a matriculation average of seventy per cent or higher with an eighty per cent or higher mark in Physics 30; and meeting the mathematics and foreign language requirements necessary to enroll in an Honours Physics program. The students meeting the set criteria consisted of students who were enrolled in their freshman year in 1966-67, 1967-68 and 1975-76 terms.

The selected group were mailed a questionnaire which solicited responses concerning their high school academic history, their preferred methods of instruction in physics; their extra-curricular activities and hobbies; school, community and immediate social group influences on their university program choice; time at which their university program was made; and their own personal reasons for making their own program choice.

The hypotheses formulated attempted to ascertain if significant differences existed between students enrolled in a physics program at the University of Alberta, and those students not enrolled in a physics program in a number of variables based on the questionnaire.

Statistical analyses of responses to the questionnaire items were compared for physics students against non-physics students for the whole group, as well as contrasting the same variables among Group I, the 1965-66 freshman, Group II, the 1966-67 freshman and Group III, the

1975-76 freshmen.

Results

A. Taken as separate groups, the following results were obtained for Group I:

1. Students whose physics teachers presented stimulating lessons had a significant tendency to enroll in a physics program.
2. Students who had science oriented hobbies had a significant tendency to enroll in a physics program.
3. Students who had literary interests had a significant tendency to enroll in a physics program.
4. Students who participated in sports had a significant tendency to enroll in a physics program.

B. Groups II and III did not show significant differences between students enrolled in a physics program as compared to those who did not enroll in a physics program on all the variables.

C. In teaching methodology, there was a significant preference for students enrolled in physics for independent rather than teacher or manual directed laboratory work as compared to those who did not enroll in a physics program.

D. Subject teachers have a high influence on program choice for both physics and non-physics students.

E. Rated 'one' in degree of influence in program selected by both physics and non-physics students were:

1. Activities and information designed to familiarize students with career opportunities.
2. Community activities and pre-university employment.
3. Reading about career fields.

F. Career choice was made during high school for 39.4 per cent of the physics students and 59.6 per cent of the non-physics students.

Conclusions

A high interest in physics coupled with stimulating presentation of material by physics teachers would seem to encourage students to enroll in a physics program after high school. The potential physics student is likely to:

a. have a science related hobby

b. be an avid reader

c. prefer a degree of freedom in laboratory work.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my advisor, Dr. Marshall Nay, whose patience and gentle prodding eventually led to the completion of this research; to Dr. Heidi Kass, for her invaluable help; to the Division of Educational Research Services for availability of facilities, and Mr. Colin Park, whose task in programming the research for analysis was formidable indeed; and, to my wife and family, for their constant encouragement.

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THE PROBLEM

Introduction

In the span of the fifteen years from 1960 to 1975, enrollment of full-time students at the University of Alberta has tripled. This increase in enrollment is not reflected equally in some departments. In particular, the enrollment in honours physics is less at the end of the fifteen year period (1975) than at the beginning (1960).

Dropping enrollments in physics has occurred in much of the western world as well, giving rise to concern in many quarters and leading to predictions of a shortage of physicists in years to come.

A questionnaire was used to gather data regarding the student's high school history, his preference for certain teaching methods, extra-curricular and leisure-time activities, along with factors from both his in-school and social world, which may have affected his choice of a university program.

The responses to the questionnaire items, answered by students enrolled in a physics program at the University of Alberta, were then compared to the responses to the same items by students enrolled in a non-physics program at the University of Alberta.

The hypotheses are based on the comparative analyses of the replies of the physics and non-physics sub-groups which responded to the questionnaire.

Rationale For The Study

At the time this study was initiated, concern was being expressed by major educational research and industrial institutions in this country, The United States and the United Kingdom, with regard to the declining enrollments in engineering and physics in universities at a time when most universities were experiencing burgeoning enrollments. Purportedly, this decline in physics enrollment would result in critical personnel shortages in the industrial nations in the near future. For a world power, such as the United States, caught in the role of world leader in technology and scientific research, such a shortage could become critical.

Available literature to be presented in this study indicated that the problem was common in the western world and its solution was being attempted on the following fronts:

a. Identification of potentially able physics students.

b. Up-grading of physics teaching in the secondary schools.

c. Research into factors which influence course choice.

d. Retention of those who graduate in the field of physics.

During the period from the early 1960's to the present, science curricula in high schools, and particularly physics curricula, have been modified. This modification has not, as yet, provided the expected increased interest in physics. In fact, the opposite has occurred. Where most faculties have had significant increases in enrollments, the enrollment in physics has not kept pace. Figures from the University of Alberta indicated that the relative and absolute enrollment in physics has actually decreased in later years.

Table I, compiled from attendance figures of day-time students enrolled at the University of Alberta as reported to the University Senate shows an increase of enrollment from about 6,000 in 1960-61 to 19,000 in 1974-75.

Table II contrasts the per cent increases in total university enrollment for the academic years 1960 to 1974, with the corresponding per cent increases in the Honours Program in Physics, Chemistry and Mathematics. These per cent increases in total university enrollments compared to the present increases in Honours Physics, Chemistry and Mathematics are vividly illustrated in Graph I.

It will be borne out in the Review of the Literature, that a variety of personal characteristics seem to identify both potential and successful scientists. If the factors which can influence a student to consider a career in physics in a positive way can be identified, and if the potential physicists are found to have certain personal qualities, likes and hobbies, then the task of the physics teacher becomes clear - to foster those interests and activities which lead students to a successful career in physics.

TABLE I

STUDENT FULL TIME ENROLLMENTS, UNIVERSITY OF ALBERTA, BY FACULTY*

	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75
AGRICULTURE	116	140	162	205	258	281	306	353	366	376	442	469	552	666	762
ARTS	694	864	1101	1185	1349	1601	1936	2275	2718	3105	3093	2841	2580	2735	2953
COMMERCE	257	304	392	521	612	608	715	764	914	1089	1119	1293	1400	1568	1774
DENTISTRY	136	161	171	192	189	192	194	185	203	193	197	192	189	192	188
DENTAL HYGIENE	-	18	39	36	32	37	41	43	46	46	50	52	65	78	78
EDUCATION	1479	1909	1977	2250	2491	2724	2902	3233	3823	4074	4290	3972	3392	3518	3676
ENGINEERING	996	889	803	749	797	850	1022	1124	1148	1311	1380	1238	1140	1167	1280
HOUSEHOLD ECONOMICS	89	87	107	98	104	152	221	296	308	330	324	294	306	387	400
LAW	120	129	127	123	136	170	189	224	246	307	366	420	471	490	472
MEDICINE	213	226	228	267	295	315	350	374	399	584	589	655	659	700	717
NURSING	114	89	105	135	156	172	164	220	309	346	240	268	266	287	307
PHARMACY	201	192	203	205	219	212	219	226	227	275	303	326	336	360	378
PHYSICAL EDUCATION	105	118	135	178	205	284	312	268	420	494	598	604	667	757	740
REHABILITATION MEDICINE	54	39	60	70	89	91	90	126	140	173	215	249	262	291	298
SCIENCE	794	861	1031	1174	1327	1357	1419	1600	1996	2419	2831	2001	2151	3146	3083
GRADUATE STUDIES	557	610	626	734	940	1125	1355	1549	1799	2088	2158	2091	2004	1867	1834
TOTAL	5968	6636	7226	8122	9195	10233	11489	13027	15182	17354	18345	18243	17757	18524	19139

* REPORT TO THE UNIVERSITY SENATE

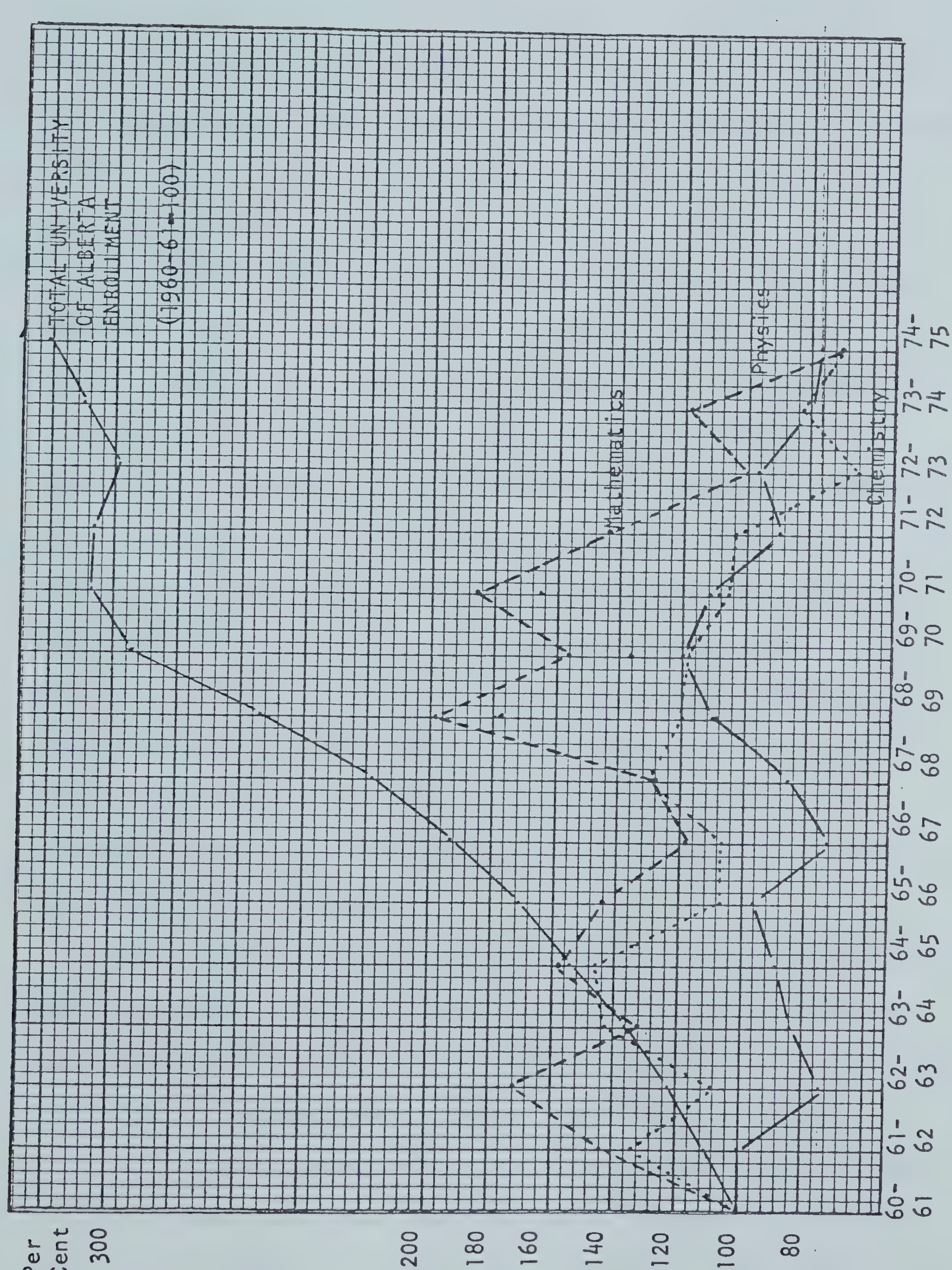
TABLE II

PER CENT CHANGE IN UNIVERSITY OF ALBERTA ENROLLMENT AND ENROLLMENTS IN HONOURS PHYSICS, CHEMISTRY AND MATHEMATICS

(1960-61-100)

ACADEMIC YEAR	PER CENT INCREASE IN UNIVERSITY ENROLLMENT	PER CENT INCREASE PHYSICS	CHEMISTRY	MATHEMATICS
1960-61	100%	100	100	100
1961-62	111%	100	134	144
1962-63	122%	74	109	172
1963-64	136%	84	143	133
1964-65	154%	89	146	158
1965-66	171%	96	107	144
1966-67	193%	73	107	118
1967-68	218%	86	130	128
1968-69	254%	111	120	197
1969-70	291%	120	118	156
1970-71	307%	112	105	185
1971-72	306%	89	104	144
1972-73	298%	96	64	100
1973-74	310%	80	82	118
1974-75	321%	77	71	69

FIGURE I



Per Cent Increase In Enrollment: University of Alberta, Honours Physics, Chemistry, Mathematics

Statement of the Problem

This research attempts to identify some of the factors which influenced student enrollment in a physics program at the University of Alberta. It attempts to determine if any relationship exists between performance in high school subjects, preferred methodology of teaching, student activities both in and out of school, and student predisposition towards physics.

Selected for this study were students enrolled at the University of Alberta, who met certain criteria in matriculation standings. Groups I and II of the study were first year and second year students respectively who were enrolled at the University of Alberta in the academic year 1967-68. Group III consisted of first year students in the academic year 1975-76. Students who met the criteria were mailed a self-administered questionnaire. The total respondents numbered 276, representing 78 per cent of the 352 questionnaires mailed. The returned questionnaires represented 43 students enrolled in a physics program or in an Honours Physics program, and 233 students who were enrolled in non-physics programs. The responses to the questionnaire were then analyzed, using the Department of Educational Research Services facilities.

The program used for statistical analysis was the Non-P-10 program. This program uses the 2 X 2 contingency tables for χ^2 and the χ^2 test for two independent variables. Where numbers are small, the resulting statistics are automatically corrected for continuity.

The respondents were divided into three groups. Each group was further divided into physics and non-physics sub-groups. Group I consisted of students enrolled in their first year in the 1967-68

term. Group II consisted of students in their second year enrolled in the 1967-68 term, and Group III consisted of students enrolled in their first year in the 1975-76 term.

Of the 258 questionnaires mailed to Group I and II students, 211 were returned, for a return of eighty-two per cent. One hundred questionnaires were mailed to students in Group III, of which 65, or 65 per cent were returned.

The questionnaire (Appendix A) solicited responses, usually in a rank form, regarding the student's academic history while in high school in term marks, best liked subject and so on; his preference with regard to teaching methodology; school, community and social group influences on his career choice; his personal reasons for choosing his university program;and the time the decision on the type of program selected was made. These responses were then compared between physics and non-physics students to determine if any significant differences could be ascertained. The anticipated differences were the basis of the proposed hypotheses.

<u>Significance of the Study</u>

At the time this study was instigated, concern was being expressed in many parts of the western world with the decline in physics enrollments in colleges and universities which, when projected, would result in an inadequate supply of personnel in future years.

A number of studies of shifts of career choices over time have been reported: Astin (1967) of project TALENT, for students from Grade 9 and Grade 12; Flanagan (1964) for Grade 9 to one year after high school graduation; Davis (1965) for college students from their freshman to senior years; and Nichols (1964) for National Merit Semi-finalists from their freshman to their senior years.

When compiled under the categories of business, science and engineering, education and professional, all the studies showed a similar pattern of change, namely, the biggest losers were engineering and science (Table III).

Astin offered the following explanation:

> "Perhaps the nature of educational curricula is such that it encourages students to take up pragmatic and applied careers such as business and education rather than theoretical and research oriented careers."

The Commission of College Physics, University of Maryland, U.S.A., in a report entitled "Preparing High School Physics Teacher" (1962), acknowledges two major problems facing the physics profession:

a. a shortage of physicists.

b. failure to communicate with the general public.

Another problem noted by the Commission:

> " A severe educational crisis for physics appears to be in the making in our high schools, where the fraction of students having a course in physics has been seriously declining. A major cause for the decline... is the shortage, or even

TABLE III

CAREER CHOICE SHIFTS OVER TIME

STUDY SAMPLE	PER CENT INCREASE				
	BUSINESS	ENGLISH	SCIENCE	EDUCATION	PROFESSIONAL
Astin (1967) Grades 9 - 12	+7.7	-4.7	-2.9	+7.2	-1.8
Flanagan (1965) Grade 9-1st year After Graduation	+7.1	-13.4	-4.4	+4.5	-3.3
Davis (1965) Freshman-Senior Year	+5.5	-6.1	+ .9*	+7.9	-2.0
Nichols (1964) Freshman-Senior Year National Merit Semi-finalists	+3.2	-17.2	-13.9	+12.3	+3.1

* The gain here is due to 1.22 % gain of Social Sciences, .49% gain of Biological Sciences, loss of .83% of Physical Sciences.

> absence, of competent physics teachers in many secondary schools."

The Times Educational Supplement (Dec. 18, 1964), reports a conference called by the University of Edinburgh, in which the problem of fifty vacancies in the Faculty of Science was discussed. The vacancies were in Chemistry, Engineering, Mathematics and Physics. This was part of a general shortage existing throughout the country, estimated to number approximately nine hundred positions. The general conclusions reached at this conference were:

a. the failure to include engineering in the school curriculum.

b. the need for more and improved science teachers.

c. the need for research into factors involved in choice of careers.

Of the sixteen faculties reported in Table IV, Science ranks ninth and Engineering sixteenth in enrollment increases for the period 1960-75.

The Faculty of Science is composed of approximately fourteen departments. The enrollment in the Department of Physics is related to this study. Enrollment figures in the general physics program are not available due to the complexity of determining the exact program in which a physics student is enrolled. Members of the Department of Physics feel that enrollment in physics has not kept pace with the general increase in enrollments in the total university.

Table V shows the enrollment in Honours Chemistry, Mathematics, and Physics (1960-75). It will be noted that for this period, Honours Chemistry enrollment, generally, is on the decline; mathematics shows a sharp drop from 1970-71 to the 1974-75 terms. Physics enrollment

TABLE IV

PERCENTAGE INCREASE IN ENROLLMENT BY FACULTY

FROM 1960 TO 1975

FACULTY	PER CENT
1. Physical Education	700%
2. Commerce	690%
3. Agriculture	657%
4. Rehabilitation Medicine	551%
5. Household Economics	449%
6. Dental Hygiene	443%
7. Arts	411%
8. Law	393%
9. Science	381%
10. Medicine	337%
11. Graduate Studies	329%
12. Nursing	270%
13. Education	249%
14. Dentistry	138%
15. Pharmacy	138%
16. Engineering	129%

TABLE V

ENROLLMENTS IN THREE HONOURS PROGRAMS IN THE FACULTY OF SCIENCE

	1960 1961	1961 1962	1962 1963	1963 1964	1964 1965	1965 1966	1966 1967	1967 1968	1968 1969	1969 1970	1970 1971	1971 1972	1972 1973	1973 1974	1974 1975
CHEMISTRY	56	75	61	80	82	60	60	73	67	66	59	58	36	46	40
MATHEMATICS	39	56	67	52	62	56	46	50	77	61	72	56	39	46	27
PHYSICS	74	74	56	62	66	71	54	64	82	89	83	66	71	59	57

peaks in 1969-70, then drops as well. The enrollment in the Honours Chemistry programs drop to 49 per cent of its peak year 1964-65; mathematics drops to 35 per cent of its peak year 1968-69; and physics drops to 64 per cent of its peak year 1969-70.

Professor H. Bondi (1975), during the 1975 International Conference on Physics Education held in Edinburgh, suggests the undertaking of studies to determine how the student is or is not attracted to the sciences.

The identification of some of the factors which influence a student in considering a career in physics is of considerable benefit to teachers, counsellors and physics departments of universities and colleges. If we can identify these factors and the particular personality traits of potential physicists, and if these potential physicists are found to prefer definite learning situations and activities, then the school and university can supply the proper climate and conditions which foster the growth of this potential and lead capable students to successful careers in physics.

DEFINITIONS

Group I Physics	-	Students in their first year at the University of Alberta enrolled in the fall term of 1967 who were in a general or Honours Physics Program.
Group I Non-Physics	-	Students in their first year at the University of Alberta, enrolled in the fall term of 1967 who were not in a general or Honours Physics Program.
Group II Physics	-	Students in their second year at the University of Alberta enrolled in the fall term of 1967 in General or Honours Physics Program.
Group II Non-Physics	-	Students in their second year at the University of Alberta enrolled in the fall term of 1967 not in a General or Honours Physics program.
Group III Physics	-	Students in their first year at the University of Alberta, enrolled in the fall term of 1975 in General or Honours Physics Program.
Group III Non-Physics	-	Students in their first year at the University of Alberta enrolled in the fall of 1975 who were not in General or Honours Physics Program.
Academic Qualifications	-	Refers to the Grade XII marks and courses accepted by the Faculty of Science for enrollment in General Physics or Honours Physics: there being five or six of English 30, Social Studies 30, Mathematics 30, Mathematics 31, Physics 30, Chemistry 30, Biology 30, Foreign Language (with Mathe-Matics 31) and Foreign Language required by Faculty. Overall average seventy per cent. Physics 30 mark eighty per cent or higher.
Teaching Methodology	-	The primary method of teaching used by the students' physics teacher.

a. Demonstrations - the use of physics equipment to demonstrate a physics principle or law.

	b. Laboratory work - the prescribed or devised laboratory investigation participated in by the class.
	c. Laboratory reports - write-up of experiments performed.
Executive and Committee Position	- Member of the governing body of those organizations which form part of a school's extra-curricular activities: a. student government b. school clubs and organizations c. community organizations
Sports Participation	- Member of school or community sports teams.
Science Activities	- Activities which are of scientific nature-electronics club, radio, science club, collecting specimen (rocks, insects, classifying, etc).
Performing Fine Arts	- Music, choir, band, etc.
Arts and Crafts	- Sculpture, modelling, sewing, weaving, etc.
Literary Activities	- Reading, newspaper, poetry, etc.
Speaking and Debating	- Reach for the Top, debating club, etc.
Service Clubs	- Boy Scouts, Girl Guides, Red Cross, C.G.I.T., etc.
Other Club Activities	- Chess club, youth club, United Nations, etc.
Influence Groups on Career Choice	- A. School personnel - teacher, principal, counsellor B. Out-of-school institutions - university, career information, career events. C. Community influences - religion, community activities, pre-university employment. D. Media - radio, television, reading. E. Immediate social groups - parents, relatives, friends.

Hypotheses

Based on previous research and related literature, the following null hypotheses are proposed:

H_1: For Group I of the experimental population there will be no significant difference between students who did enroll in a physics program as compared with students who did not, for each of the following academic factors:

$H_{1.1}$: Marks achieved in physics.

$H_{1.2}$: Interest expressed by student in physics.

$H_{1.3}$: Student's perception of challenge in physics.

$H_{1.4}$: Student's perception of teacher's knowledge of physics.

$H_{1.5}$: Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.

$H_{1.6}$: Interest generated by teacher in the presentation of physics.

H_2: For Group II of the experimental population there will be no significant difference between students who did enroll in a physics program as compared with students who did not, for each of the following academic factors:

$H_{2.1}$: Marks achieved in physics

$H_{2.2}$: Interest expressed by student in physics.

$H_{2.3}$: Student's perception of challenge in physics.

$H_{2.4}$: Student's perception of teacher's knowledge of physics.

$H_{2.5}$: Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.

$H_{2.6}$: Interest generated by teacher in the presentation of physics.

H_3: For Group III of the experimental population there will be no significant difference between students who did enroll in a physics program as compared with students who did not, for each of the following academic factors:

$H_{3.1}$: Marks achieved in physics.

$H_{3.2}$: Interest expressed by student in physics.

$H_{3.3}$: Student's perception of challenge in physics.

$H_{3.4}$: Student's perception of teacher's knowledge of physics.

$H_{3.5}$: Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.

$H_{3.6}$: Interest generated by teacher in the presentation of physics.

H_4: For Group I of the experimental population there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for involvement in the following extra-curricular activities:

$H_{4.1}$: Executive and committee positions.

$H_{4.2}$: Sports.

$H_{4.3}$: Science activities.

$H_{4.4}$: Fine arts.

$H_{4.5}$: Arts and crafts.

$H_{4.6}$: Literary activities.

$H_{4.7}$: Speaking and debating.

$H_{4.8}$: Service clubs.

$H_{4.9}$: Other club activities.

H_5: For Group II of the experimental population there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for involvement in the following extra-curricular activities:

$H_{5.1}$: Executive and committee positions.

$H_{5.2}$: Sports.

$H_{5.3}$: Science activities.

$H_{5.4}$: Fine arts.

$H_{5.5}$: Arts and crafts.

$H_{5.6}$: Literary activities.

$H_{5.7}$: Speaking and debating.

$H_{5.8}$: Service clubs.

$H_{5.9}$: Other club activities.

H_6: For Group III of the experimental population there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for involvement in the following extra-curricular activities:

$H_{6.1}$: Executive and committee positions.

$H_{6.2}$: Sports.

$H_{6.3}$: Science activities.

$H_{6.4}$: Fine arts.

$H_{6.5}$: Arts and crafts.

$H_{6.6}$: Literary activities.

$H_{6.7}$: Speaking and debating.

$H_{6.8}$: Service clubs.

$H_{6.9}$: Other club activities.

H_7: For the entire experimental population (Groups I, II and III combined), there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for each of the following influence groups:

$H_{7.1}$: Group A (School Personnel).

$H_{7.2}$: Group B (Out of school institutions).

$H_{7.3}$: Group C (Community influences).

$H_{7.4}$: Group D (Media).

$H_{7.5}$: Group E (Immediate social groups).

H_8: For the entire experimental population (Groups I, II and III combined), there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for each of the following preferred method of instruction in physics:

$H_{8.1}$: Teacher versus student demonstrations.

$H_{8.2}$: Note-taking.

$H_{8.3}$: Laboratory work.

$H_{8.4}$: Class discussions.

$H_{8.5}$: Assignments.

$H_{8.6}$: Projects.

$H_{8.7}$: Testing.

$H_{8.8}$: Laboratory reports.

H_9: For the entire experimental population (Groups I, II and III combined), there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for the following miscellaneous factors:

$H_{9.1}$: Attendance at a high school in a community of population less than 2,500; in a town of population over 2,500; in a city.

$H_{9.2}$: Preference of the student to work alone or with a group.

$H_{9.3}$: Preference of a student to participate in individual or team sports.

<u>Limitations</u>

Small numbers resulting from divisions and sub-divisions of respondents in this study are likely to make statistical analyses difficult, and some conclusions not very firm. The findings, as a result of small groupings, cannot be generalized for the entire population.

As will be explained more fully in the Design of the Study, the respondents to the questionnaire used in this study will be divided into three groups. Group I represents the respondents who were in their first year of university in 1967. Group II represents those respondents in their second year in 1967, and Group III represents those respondents who were first year students in 1975. Each of these groups is further divided into two classes or categories:

1. The Physics class (enrolled in general or Honours Physics).
2. Non-Physics.

In 1971, Departmental Examinations for Grade XII were discontinued. Thus, the respondents in the year 1967 wrote departmentals (the final marks of which were composed of fifty per cent teacher evaluation and fifty per cent from the written final). The 1975 respondents did not write Departmental Examinations and their marks were entirely determined by teacher evaluation.

Knowles (1964) reports a high correlation between departmental averages and principal's rating. These two variables - departmental averages and principal's rating - showed the greatest overall correlation to freshman success. The principals' ratings, when they were required by the Department of Education, consisted of the estimated student marks in departmental subjects as compiled by the teachers who taught the subject. In reality, the principals' ratings were

really 'teacher ratings'. If, then, departmental scores and teacher scores were highly correlated, as reported by Knowles (1964), one might assume that although the Grade 12 marks for the 1967 respondents vis-a-vis the 1975 respondents were assigned by different means, the overall effect of this difference on the study would be minimal. However, reports from the university indicate that student high school marks have been about fourteen per cent higher than normal. It is possible that without the June departmentals, teacher's general gradings have slowly increased, so that Groups I and II compared to Group III may not really be representative of the same population. There may also be societal influences making Group III different from Groups I and II.

Where Groups I, II and III are combined for the study, the results will be used only to determine what factors, if any, have not changed over time.

Due to lack of numbers, analysis of Group I, II and III separately in some variables make conclusions extremely difficult to form. In such instances, the groups are combined. The results from such combinations can only indicate trends and do not lead to any firm conclusions.

It is understood that when a questionnaire is given, a bias results. Although random samples may be used, respondents to a questionnaire will differ from non-respondents, thus producing a bias.

Delimitations

For the purpose of this study, the students selected were limited to those matriculants who were enrolled at the University of Alberta, Edmonton, Alberta. The original group consisted of those students who had written Grade 12 Departmental Examinations in June of 1966 and 1967, who had applied and had been admitted to the University of Alberta. Students attending other universities or colleges who graduated from high school during the same period did not form part of this group.

As described in the Design of the Study, selected students were those who, as part of university-matriculation requirements, had Physics 30, Mathematics 31 and a foreign language.

The Department of Education supplied the university with transcripts of student records for those students who had made application to the university. These transcripts were then compiled into a single file at the office of the Registrar, University of Alberta.

Student transcripts containing only three Departmental Examination marks, one of which was Physics 30 with a grade of 80 per cent or better, were also selected and researched to determine remaining criteria. Student transcripts consisting of two Grade 12 Departmental Examination scores were not selected. During the school term 1965-66 and 1966-67, very few high schools in the Province of Alberta were using the semester system. The Lindsay Thurber High School in Red Deer, Alberta, operated, as it still does, on the trimester system. Students from such schools, whose June transcripts from the Department of Education contained two or three Grade 12 subject scores, were not selected unless one of the subjects taken was Physics 30 with the required 80

per cent or better score.

The study was delayed to the present year by various circumstances. It was this delay which offered an opportunity to do a comparative study on the problem. Therefore, the format of the investigation was modified accordingly. Consequently, an attempt was made to obtain another group of students fitting the same criteria as was used for the 1966 and 1967 groups. This new group represents students who attended the University of Alberta, 1975-76 being their freshman year. This would be a comparison of the 1966-67 group and the 1975-76 group on the same variables. However, the identification of the 1975 group proved to be a considerable problem. The principle of confidentiality of student files at the University of Alberta became an unsurmountable obstacle.

Permission to select the desired students from the files of the university was denied by the president of the Student's Union. A second, and perhaps the most formidable task in the selection of the required students came about due to a change in the format of record keeping as now practiced by the Registrar's office at the university, from whose files the previous group had been selected. The 1966-67 group transcripts were available in yearly folders. However, the 1975-76 group information was not available by the same system. Upon receipt of a transcript from the Department of Education, the office of the Registrar now places the transcript in the student's folder in alphabetical order in the general files, which number in the neighbourhood of one hundred thousand. The task of searching these files for the required 1975-76 students would be overwhelming.

The Research, Development and Examinations Branch of the Department of Education was able to select the names of one hundred students

whose Grade 12 marks corresponded with the set criteria for this study, who had requested their transcripts be sent to the University of Alberta. This group of one hundred was all the Department of Education could supply.

The difficulty in obtaining the maximum number of students for the 1975-76 group will make the findings of the comparative study tentative and uncertain.

Many of the items under the various headings in the questionnaire were not used either because they were not too appropriate to the study of the problem or because of difficulty in computer programming. Under "University Program Information", responses to the following items were not used:

1. In what faculty are you presently enrolled?

4. Towards what degree are you presently working?

Under "High School History", the ranking of the subjects was used only to ascertain the relative position of physics. In "Teaching Methods Used by Teachers", responses under "Science Teacher" and "Physics Teacher" were not used due to the difficulty of setting up a program for analysis.

CHAPTER II

REVIEW OF PERTINENT LITERATURE

Introduction

The search for scientific talent, its identity and utilization, has been the subject of a number of studies. The predictions of the 1950's and 1960's of personnel shortages in the sciences and engineering fields in future years resulted in studies relating to identification of scientific talent, in upgrading of science programs in schools and studies into the decreasing enrollments of students in the sciences in schools and universities. Large industrial firms and corporations such as Westinghouse, du Pont, Dow Chemical and Eastman Kodak, have spent large sums in the development of tests designed to measure science potential in students, as well as providing summer institutes and science-oriented programs for those identified as having science potential (Vlassis 1965).

Numerous studies into the personality of scientists, their interests and activities, have been conducted. The results of these studies are, at times, contradictory, and generalizations are difficult to defend.

In spite of conflicting conclusions resulting from the reported studies, the majority of studies indicate that scientists have characteristics of personality, activities, social interactions, learning preferences and other psychological traits, which differ from the non-scientists.

Predicted shortages in science personnel did not materialize. On the contrary, at present, there appears to be an over supply of Ph. D's in Physics and Chemistry. This is not to say that research opportunities

are lacking. Many fields of study are in need of research, environment and energy resources to mention but two. Perhaps the cause of the over supply of science personnel lies in the dependency of research on government funded projects. The nature of research has changed so that governments give the main impetus to research. Restriction in government spending has an immediate effect on industries dependent on large government contracts. The effects of such restrictions are soon felt by graduating scientists and researchers.

Research On Declining Enrollments in Sciences

Declining enrollments in physics at universities and colleges are well documented. During the period 1960 to 1975, the enrollment of day-time students at the University of Alberta increased over three hundred per cent, yet the number of Honours Physics students, except for a slight recovery in 1969, has decreased below the 1960 level. Similar patterns are evident for Honours Chemistry and Honours Mathematics enrollments.

The declining enrollments in the sciences over this period of time has led to predictions of critical shortages of personnel in the future. Although these predictions did not materialize, as previously mentioned, the situation, nonetheless, caused concern in many parts of the world at that time.

In spite of interest in scientific talent taken by large industrial firms, interest in physics appears to maintain its decline. Bromley (1972) reports a continuous decline in enrollment in physics in the United States since 1948. America's world position in physics is threatened by lack of federal funding, according to Bromley.

In a lecture given at the International Conference on Physics Education at Edinburgh in 1975, Professor H. Bondi expressed worry about the decreasing appeal of science and engineering subjects to young people, resulting in diminishing numbers of students in the sciences. In the long run, this situation will lead to dilution of the quality of students selected. Dr. Bondi pointed out the need to carry out a "market research" to determine how the consumer "student" is attracted to the sciences. A greater problem, he suggested, is with the young people who have chosen not to enter the sciences. He stressed the need for good physics teachers in our schools.

On a similar vein, Science News (Sept. 1974), in an article under the title, "Science Education" reported declining applications for science and engineering courses, a situation which is worrying British academic establishmentarians. Applications from English-speaking students is decreasing at an alarming rate. The report further stated that a similar decline in enrollments for scientific and technical degrees is occurring in the United States.

Causes of Decline in Enrollments

A variety of causes for the decline in enrollments in the sciences in general, and physics in particular, have been put forth.

A survey conducted by Susanne Ellis (1973), of the American Institute of Physics, Manpower Division, indicated the following:

a. decrease in the fraction of graduates employed by industry in physics-related jobs.

b. the percentage of students with a bachelor's degree in Physics entering medical schools continues to increase.

c. fewer students with a bachelor's degree in physics are entering graduate work in physics.

d. many graduates are forced to take jobs that make little use of their physics background.

The movement into non-physics fields is probably a readjustment of graduates to an inhospitable economic environment. It would appear that industry is very sensitive to government spending priorities. Thus, the availability of government funds in physics research projects results in a discontinuous availability of jobs. This on-again, off-again, approach to research funding is bound to discourage the entry of potential scientists into science careers.

Reitz (1973), investigating the shift away from science and engineering in the early 1960's, theorized the possibility of student reaction to the Korean and Vietnam wars, and the role played by science in these wars caused the shift from science (physical), to the social sciences and the humanities. He found, however, that the social sciences were not the beneficiaries of this flight from science. The professions and managerial fields showed a significant increase in enrollment during this period.

Dietrich (1973), reports a decline in physics enrollment in the United States high schools from 25.8 per cent to 18.9 per cent for the period 1948 to 1965. In comparing teacher grades in physics in 'high physics enrollment' schools, to 'low physics enrollment' schools, Dietrich found that, generally, physics teachers in 'high physics enrollment' schools marked more severely than their counterparts in the 'low physics enrollment' schools.

It would appear that there is little evidence to suggest that the

'difficulty level' of physics, or, the 'disenchantment' of youth with science, are factors contributing to declining enrollments. Neither is physics low in prestige. In a study of 623 students at San Diego College by DeLora, Harder and Kidwell (1964), physics was ranked 4.5 on a 49 point scale, when asked to rank college majors. The most frequent response (36 per cent) to the characteristics of the most respected majors were 'intellectual difficulty', 'most demanding' and 'requiring great ability'. Ranked ahead of physics were pre-medicine, engineering, commerce and pre-law. There is agreement between this study and that of Reitz, wherein the professions and managerial fields appear to be reaping the "benefits" of the decreasing enrollments in science. Yet, although engineering is ranked second only to pre-medicine, engineering enrollments are reported declining in Great Britain, the United States and Canada.

Cole (1956), on the basis of various studies in the United States concerning future requirements for scientific manpower, predicts an ever-growing shortage of scientific talent. He underscores the decline in the attraction of science which occurs between high school and college. The failure of many of the best high school students to go on to college, he relates to the educational priorities of the governments of various states. Cole found a high correlation between the number of students attending college, and:

a. the per classroom expenditures in a given state

b. the average teaching salary in the state

c. the average per capita income in the state

d. the average per pupil expenditure

By and large, the greater the state's expenditure for public

education, the greater the proportion of college age youth attending colleges.

It is argued that the government has some responsibility in the development and nurture of scientific talent.

Cole (1956) lists a number of obstacles to the production of scientists:

a. Failure to seek out necessary information for a scientific career.

b. Change of heroes from the inventor and scientist to the star athlete and television star.

c. Peer group influences.

d. For girls, the accepted feminine role.

e. Parental and family influence, particularly as it relates to family attitude towards things intellectual.

f. The size and nature of the community in which the student lives, and its facilities and opportunities for intellectual endeavours.

g. The general attitude or view by the general public of scientists and science.

Cole (1956) states the following potential factors encouraging careers in science:

a. Programs sponsored by professional and business organizations.

b. Programs for encouraging and upgrading science teachers.

c. Government support.

d. The home and community.

e. The school in providing an 'enquiring' climate, staffing and program offerings.

f. Programs for the gifted child.

g. Teacher supply.

h. School güidance program.

Cole (1956) concludes that the shortage of scientific talent is not subject to any single solution. The loss of talent is partly due to poor high school teaching; outside school deterents play a role in the loss of scientific talent, and a lack of sufficient financial support contributes to this loss.

Psychological Characteristics of Scientists

The literature pertaining to psychological differences between scientists and non-scientists, although contradictory, weighs in favour of there being discernible differences. Roe (1952), in her study, found distinct patterns in the life histories of her subjects. Some 50 per cent came from selected families where fathers were professional men. More than usual, these scientists were placed on their own resources early in life, either through loss of a parent, or the parents being occupied in their own professions, leaving them to their own devices. Most of the scientists could be described as 'loners', finding satisfaction away from personal relationships. This pattern is verified by Eiduson (1962), whose research into the lives of forty research scientists, indicated that most had had experience with periods of isolation early in their lives, and almost one-half of her group had lost a father early in life. There is close agreement between the group studied by Roe (1952) and Eiduson (1962) with regard to the lack of family ties, or close personal relationships with others.

Terman (1954), found that scientists, as a group, have poor social adjustments as compared to non-scientists.

Shannon's (1947) study of biographies of 250 world renowned research workers, found that those in the physical sciences rated higher on the traits of anti-sociability, non-sociability independence, dissatisfaction and skepticism than social scientists.

Simono (1965), found significant differentiation between science and non-science majors while in high school in one of the three indices used in the study. Non-science majors were distinguished by involvement in reading activities, while science majors preferred mechanical or technical hobbies.

Blake (1965), compared students choosing a science career who lack the interests of scientists with those that have the interests of scientists, after giving each group a variety of test inventories. His findings indicated that students who had interests of scientists are 'inner directed', while those that lack the interests of scientists are 'other directed'. Students who lack the interests of scientists perceive scientists to have social desirability. They are more extroverted. Those students having the interests of scientists are more introverted and less socially adjusted.

A number of studies reported little, if any, differences in personality traits of scientists as compared to non-scientists. Strauss (1957) in his study of 89 Ph. D's in Physics, Chemistry and Engineering, found a lack of discernible peculiarities which would differentiate them from others, engaging in normal high school and collegiate extra-curricular activities. Vineyard (1959), found little difference in characteristics between science and non-science students, except that science students

tended to be somewhat more serious and restrained, and more dominant than non-science students.

Other Influences

Relationships between a choice of a science career and other variables such as intelligence, residence and socio-economic groups showed the findings tend to be contradictory. Koelsche (1965), studied 54 State Science Fair award winners. Of this group, fifty per cent came from schools of five hundred or more students. Stranberg (1966), in studying the relationship between teacher characteristics and science achievement, found that when intelligence factors were removed, rural pupils achieved higher results than city pupils. It would appear that science potential is not lacking in the smaller rural schools. A variety of residence combinations were reported by Pennington (1960). Students who had village-town-city combinations showed the highest interest in science. The next highest was country-city and the lowest was country-village-city combinations. One might infer a strong positive effect of city residence on science interest. Yet, Cole (1956), suggested that large cities inhibit intellectual growth in spite of their cultural attraction. Strauss and Rainwater (1962), in their study of 1,789 chemists, found that one-third were from blue collar groups, and one-quarter were from white-collar and managerial groups. Few originated from farm families. This study indicates a strong influence of large towns and cities in the development of interest in science (chemistry).

High intelligence is not considered a prime factor in many of the Ph. D's in Strauss' study. Thirty-eight per cent had an I.Q. of 120 or

less, and all ranked in the top fifty per cent of their class. As to the query, "How much intelligence is needed to be a scientist?". forty per cent gave the answer as average. What was required were such traits as interest and drive.

Studies of Factors Affecting Career Choices

Most research findings reported a strong influence on science interest by teachers and educational experiences.

Teacher methodology appears to have a stimulating effect on interest in science. Pennington (1960), reported that physics students preferred units of study organized by both teacher and students, preferred a balance of lecture, discussion, workbook and reading time, and preferred adequate laboratory instruction. The students also preferred experiments requiring thinking, related to study, with experimental manuals requiring descriptive or fill in the blank, write-ups of laboratory work. Walberg (1967), after giving 725 boys and 332 girls a Science Activity Inventory, found that boys, generally, prefer the manipulative and experimental method, while girls preferred the discussion-questionning method. Wynn and Bledsoe (1967) reported that, for those students with high interests and aptitude in science, a contribution to this interest factor was laboratory experiences.

Pennington (1960), suggested science-oriented organizations as having a strong influence on science interests. Edgerton (1943), reports the influence of professors and teachers as high, for all professional groups except physicians. In answer to the query, "Was there someone who did something that influenced you to make this decision (on Graduate education)?", Gropper and Fitzpatrick (1959) reported that students

did not deny faculty influence, but said that faculty (both in high school and college) had much more to do with choice of field than with advanced education. Cole (1956), lists a number of factors which may have a high potential for encouraging careers in science. Among these are programs sponsored by professional and business organizations, programs for the gifted child, programs for encouraging and upgrading science teachers, and the school itself, in providing an inquiring climate, adequate staffing and program offerings.

Strauss (1957) concluded in his study, that many of his Ph. D's were strongly affected by personal interest taken in them by their science teacher. Members of his study group, who attended large city schools, did not report any strong teacher influence, whereas, those from smaller schools reported being impressed by their teacher. Wynn and Bledsoe (1967) credit such factors as influential teacher, parents, scientist friends, science courses and laboratory experiences in stimulating science interests.

Roe (1952), in her many interviews with emminent biologists and physicists, reported teacher methodology as having little influence as perceived by her subjects. Many were not in the least impressed by their teachers, other than the fact that they were allowed to tinker with laboratory apparatus on their own, without structure or guidance.

Time of Career Choice

At what point in their lives do scientists choose a scientific career? Strauss and Rainwater (1962), reported that 55 per cent of the chemists in their study had made the decision pertaining to their careers during high school. In his study of State Science Fair winners,

Koelsche (1965), reported interest in science to have occurred during grades four to eight. Snelling and Boruch (1970), reported that 50.4 per cent of 2,045 physics majors had chosen science as their major field prior to grade nine. The general concensus is that science interest develops during the late elementary grades, with science careers being considered as early as Junior High School. It would appear that the high school, with its divisions of science into chemistry, physics and biology, can play an important role in helping those students interested in science, to finalize their choice of science program.

Summary of Literature

Though somewhat inconclusive, some discernible characteristics of scientists are evident. Their interests in science develop early in their school years. Their interest in science is fostered by personal interest of their science teachers and adequate laboratory experiences related to their study. They are, generally, if not anti-social, at least non-social, having few close personal relationships. The quality most frequently reported as essential to a successful career in science was 'drive'. In the few instances reported, job considerations were of little importance. Educational and research considerations were paramount, over vocational advantages (Gropper and Fitzpatrick 1959).

If the factors which can influence a student to consider a physics career in a positive way can be identified; if the potential physicists are found to have certain personal qualities, likes and hobbies, then one of the tasks of the physics teacher is to foster those interests and activities which may lead students to a successful career in physics.

CHAPTER III

DESIGN OF THE STUDY

Introduction

The study was undertaken to determine what factors influence a student's choice of a university program, particularly what influences a student's choice of a physics program. The factors could include school academic achievement, home and community influences, personal interests and activities, and information on careers available to students. To gather appropriate data, a questionnaire was devised and administered to a selected group of University of Alberta students in the form of a pilot study. The questionnaire was then revised in the light of responses by the pilot group and with the advice of a panel of graduate students in the Department of Secondary Education, University of Alberta.

The revised questionnaire was then mailed to students enrolled in the University of Alberta, who met certain academic criteria. The responses to the questionnaire were then statistically analysed to determine if significant differences existed between students enrolled in a physics program and those enrolled in other programs, in selected variables.

The Questionnaire

The questionnaire attempts to explore those areas which may contain factors which contribute to a student's choice of university program. These areas are:

a. the matriculation courses which the student takes.

b. science methodology to which the student is exposed.

c. the types of extra-curricular activities in which the student participates.

d. the groups within the school and the community which may exert some influence on the student.

e. the personal reasons for his program decision.

In the first section of the questionnaire, the student is asked to rank his matriculation subjects according to his highest mark achieved; most challenging; most work required; teacher knowledge of subject matter; and stimulating lesson presentation.

The second section of the questionnaire is designed to explore the methodology used, or perceived by the student as being utilized by the physics teacher and what the student himself prefers. This section touches on pedagogical strategies used by the physics teacher in the areas of lectures, notes, projects and laboratory experiences.

The third section is concerned with student interests, activities and hobbies within the school and in the community.

Section four ranks individuals within groups with respect to the degree of influence on student program choice. These groups are the school, community, media, planned career programs, and family and friends.

The last section seeks to determine the most common reasons given for choice of program made, and the time the choice was made.

The questionnaires were mailed to those students selected according to the set criteria. The questionnaires were self-administering and asked the students to respond to most questions in a ranking order, with some statement-form answers required. The questionnaires were then returned to the author by return postage.

The replies from the questionnaires were then placed on computer cards and the analyses carried out, using the computer facilities of the University of Alberta and personnel in the Division of Educational Research Services.

A sample questionnaire is given in Appendix A.

Originally, the group selected were students in their first and second year at the University of Alberta in 1967, who met the specified criteria. Due to unforeseen circumstances, the study was delayed until 1975. This afforded an opportunity to compare the 1967 and 1975 groups in the same selected variables.

The Pilot Study

In order to test the appropriateness of the items in the questionnaire, a group of twenty University of Alberta students meeting the academic requirements set, were mailed a questionnaire. The students were selected at random from the list of the total eligible population. Of the twenty students responding, fifteen were enrolled in Science and Engineering, five in other faculties. The responses (Appendix B) led to refinement of the questionnaire and to the formulation of the hypotheses associated with the study.

Population In The Study

In order to determine what factors would influence a student to enroll in a physics or Honours Physics program in the Faculty of Science, the student must present the necessary high school matriculation standings. In consultation with personnel in the Faculty of Science, it was determined that a student would probably be accepted for a general physics program or an Honours Physics program if he presented a matriculation average of seventy per cent or higher, with

Mathematics 31 and a Foreign Language, as part of his matriculation subjects. In order to investigate why capable physics students do or do not choose a physics program when enrolling at the University of Alberta, the required Physics 30 mark as part of his matriculation requirements was set at eighty per cent or higher. Students meeting the above criteria then would, by the nature of their grade twelve marks, indicate a high ability in physics, and an academic record which would enable them to enroll in either a general or Honours Physics program.

The replies from the questionnaire were divided into three groups, each group being further sub-divided into physics and non-physics sub-groups as follows:

	Physics	Non-Physics	Total
Group I (1967 Freshmen)	25	92	117
Group II (1967 Sophomores)	12	82	94
Group III (1975 Freshmen)	6	59	65
Total	43	233	276

Modification of Ranking Scheme

In questions 6 to 11 inclusive of the questionnaire, a student is asked to rank his marks received in the seven departmental subjects from highest to lowest. It is conceivable that a student could choose a physics program at university having achieved a high mark in Physics 30, but not necessarily the highest mark in all his possible seven subjects. It can be argued that a ranking of 1, 2 or 3 in a physics mark in the top three of seven subjects, could influence him in choosing a physics program. Stated in a different way, a Physics 30 ranking of three need

not necessarily discourage him from enrolling in physics. Therefore, students who ranked Physics 30 as 1, 2 or 3 in highest marks achieved are classed as 'high marks in physics'.

A similar recategorization was carried out for questions 7 to 11 inclusive.

Question 7: Subject ranked from most interesting to least interesting.

Question 8: Subjects ranked from most challenging to least challenging.

Question 9: Teacher knowledge of subject ranked from most knowledgeable to least knowledgeable.

Question 10: Subjects ranked according to hardest work input by student to least work input.

Question 11: Subjects ranked according to most stimulating presentation by teacher to least stimulating presentations.

Questions 13, 16 and 17 deal with organizations, hobbies or activities, and community activities under separate questions. For ease of analyses, these were taken together in one question under nine categories:

1. Executive and Committee Positions.
    a. Student Union executive position.
    b. Club executive position.
    c. Community organizations, executive positions.
2. Sports Participation:

    Member of school or community sports teams.

3. Science Activities:

   Activities which are of scientific nature - electronics club, radio, science club, collecting specimen (rocks, insects, classifying, etc).

4. Performing Fine Arts:

   Music, choir, band, etc.

5. Arts and Crafts:

   Sculpture, modelling, sewing, weaving, etc.

6. Literary Activities:

   Reading, newspaper, poetry, etc.

7. Speaking and Debating:

   Reach for the Top, Debating club, etc.

8. Service Clubs:

   Boy Scouts, Girl Guides, Red Cross, C.G.I.T., Etc.

9. Other Club Activities:

   Chess club, youth club, United Nations, etc.

Student participation in science fairs, as indicated in questions 14 and 15, was included in 'Science Activities'.

Statistical Analyses

For all the variables in the questionnaire, the 'physics' students, or, those enrolled in a general or Honours Physics program, are compared to the non-physics group,or, those students not enrolled in a general or Honours Physics program. The two groups are, therefore, independent. The χ^2 test for two independent groups will be used throughout. In most instances, the 2 X 2 contingency tables are utilized.

	Variable High	Low	
Physics	A	B	A + B
Non Physics	C	D	C + D
	A + C	B + D	N

A, B, C, and D are the numbers in each cell representing the group characteristic.

$$\chi^2 = \frac{N\left(\left|AD - BC\right| - \frac{N}{2}\right)^2}{(A+B)(C+D)(A+C)(B+D)} \qquad df = 1 \qquad (1)$$

In other tests of significance, the χ^2 equation for two independent samples will be used, namely:

$$\chi^2 = \sum_{i-1}^{r} \sum_{j=1}^{k} \frac{(0_{ij} - E_{ij})^2}{E_{ij}} \qquad (2)$$

Where 0_{ij} = observed number of cases categorized in the ith row of jth column.

E_{ij} = number of expected cases under H_o to be categorized in the 1th row of the jth column.

df = (r-1)(K-1)

r = number of rows

k = number of columns

The χ^2 test for two independent samples is chosen because the two groups (physics and non-physics) are independent and because each ranked variable under study is discrete (high or low rank).

Equation 1 was used when 2 X 2 contingency tables are used.

Equation 2 was used where contingency tables had degrees of freedom greater than 1. (Siegal, 1956).

The program selected for analyses was the non-P-10 (Division of Educational Research Services Library). Where cell population is small, the program automatically corrects for continuity.

Questions 21, 22, 23 and 24 were not treated statistically; the data from the responses given a number one ranking were counted.

Due to the small number of "physics" students in each group, the total sample (Groups I, II and III) were combined when dealing with hypotheses 7, 8 and 9. The fact that Group III could be considered as being from a different population than Groups I and II, any significant differences between physics and non-physics students cannot be justified. However, any resulting significant differences may be viewed as merely "indications" or trends.

CHAPTER IV

RESULTS, ANALYSIS AND DISCUSSION

Introduction

The data obtained from the questionnaires and their statistical analyses in the form of contingency tables is given in Appendix C. This data is condensed and given below in tabular form in conjunction with the test of each null hypotheses (Tables VI-XIV). The remainder of the data is tabulated on the basis of number one ranking (Tables XV-XVIII). Subsequent to this, the findings are summarized and discussed.

Summary of the Test of Hypotheses

Only the following sub-hypotheses were rejected at the 0.05 level of confidence: $H_{1.6}$, $H_{4.2}$, $H_{4.3}$, $H_{4.6}$, $H_{8.3}$.

Of the academic factors, only interest generated by the physics teacher in the presentation of physics showed a significant difference between physics and non-physics students. This was true for Group I only.

Of the extra-curricular activities, differences between physics and non-physics students were significant only for Group I in participation in sports, science related activities and literary activities.

Analysis and Discussion

Group III was considerably smaller than either Group I or II, particularly in the number of 'physics' students in the group. It is, therefore, not surprising that for this group significant differences between the physics and non-physics students did not occur in any of the variables. The numbers of physics students (6) is probably too small, even with the correction factor, to produce meaningful results.

TABLE VI

EFFECT OF ACADEMIC FACTORS ON PROGRAM CHOICE

OF PHYSICS AND NON-PHYSICS MAJORS. (GROUP I)

Sub-Hypothesis	Variable	x^2	df	p value
$H_{1.1}$	Marks achieved in physics	.84	1	.36
$H_{1.2}$	Interest expressed by student in physics	2.48	1	.11
$H_{1.3}$	Student's perception of challenge in physics	.05	1	.87
$H_{1.4}$	Student's perception of teacher's knowledge of physics	.27	1	.64
$H_{1.5}$	Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.	.79	1	.18
$H_{1.6}$	Interest generated by teacher in the presentation of physics	5.92	1	.015

TABLE VII

EFFECT OF ACADEMIC FACTORS ON PROGRAM CHOICE

OF PHYSICS AND NON-PHYSICS MAJORS. (GROUP II)

Sub-Hypothesis	Variable	x^2	df	p value
$H_{2.1}$	Marks achieved in physics	.04	1	.85
$H_{2.2}$	Interest expressed by student in physics	1.50	1	.22
$H_{2.3}$	Student's perception of challenge in physics	2.43	1	.12
$H_{2.4}$	Student's perception of teacher's knowledge of physics	2.14	1	.14
$H_{2.5}$	Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.	.00	1	.96
$H_{2.6}$	Interest generated by teacher in the presentation of physics	1.16	1	.28

TABLE VIII

EFFECT OF ACADEMIC FACTORS ON PROGRAM CHOICE

OF PHYSICS AND NON-PHYSICS MAJORS. (GROUP III)

Sub-Hypothesis	Variable	x^2	df	p value
$H_{3.1}$	Marks achieved in physics	.02	1	.88
$H_{3.2}$	Interest expressed by student in physics	1.03	1	.31
$H_{3.3}$	Student's perception of challenge in physics	.11	1	.74
$H_{3.4}$	Student's perception of teacher's knowledge of physics	.93	1	.34
$H_{3.5}$	Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.	1.1	1	.29
$H_{3.6}$	Interest generated by teacher in the presentation of physics	.77	1	.38

TABLE IX

EFFECT OF EXTRA-CURRICULAR ACTIVITIES ON PROGRAM CHOICE OF PHYSICS AND NON-PHYSICS MAJORS. (GROUP I)

Sub-Hypothesis	Variable	x^2	df	p value
$H_{4.1}$	Executive and committee positions	.31	1	.58
$H_{4.2}$	Sports	7.55	1	.006
$H_{4.3}$	Science activities	13.13	1	.003
$H_{4.4}$	Fine Arts	.035	1	.85
$H_{4.5}$	Arts and crafts	.00	1	.99
$H_{4.6}$	Literary activities	6.12	1	.013
$H_{4.7}$	Speaking and debating	.00	1	.99
$H_{4.8}$	Service clubs	.00	1	.99
$H_{4.9}$	Other club activities	.025	1	.87

TABLE X

EFFECT OF EXTRA-CURRICULAR ACTIVITIES ON PROGRAM CHOICE OF PHYSICS AND NON-PHYSICS MAJORS. (GROUP II)

Sub-Hypothesis	Variable	x^2	df	p value
$H_{5.1}$	Executive and committee positions	.003	1	.96
$H_{5.2}$	Sports	.01	1	.91
$H_{5.3}$	Science activities	1.15	1	.28
$H_{5.4}$	Fine arts	1.50	1	.22
$H_{5.5}$	Arts and crafts	.11	1	.74
$H_{5.6}$	Literary activities	.61	1	.43
$H_{5.7}$	Speaking and debating	.001	1	.97
$H_{5.8}$	Service clubs	.15	1	.70
$H_{5.9}$	Other club activities	.035	1	.85

TABLE XI

EFFECT OF EXTRA-CURRICULAR ACTIVITIES ON PROGRAM

CHOICE OF PHYSICS AND NON-PHYSICS MAJORS. (GROUP III)

Sub-Hypothesis	Variable	x^2	df	p value
$H_{6.1}$	Executive and committee positions	.054	1	.82
$H_{6.2}$	Sports	.68	1	.41
$H_{6.3}$	Science activities	.56	1	.45
$H_{6.4}$	Fine arts	1.55	1	.21
$H_{6.5}$	Arts and crafts	.45	1	.50
$H_{6.6}$	Literary activities	.005	1	.94
$H_{6.7}$	Speaking and debating	.054	1	.82
$H_{6.8}$	Service clubs	.31	1	.55
$H_{6.9}$	Other club activities	.064	1	.80

TABLE XII

EFFECTS OF INFLUENCE GROUPS ON PROGRAM CHOICE OF

PHYSICS AND NON-PHYSICS MAJORS. (GROUPS I, II and III COMBINED

Sub-Hypotheses	Variable	x^2	df	p value
$H_{7.1}$	Group A (School Personnel)	2.29	2	.30
$H_{7.2}$	Group B (Out of school institutions)	1.12	2	.50
$H_{7.3}$	Group C (Community influences)	.34	2	.80
$H_{7.4}$	Group D (Media)	3.14	2	.20
$H_{7.5}$	Group E (Immediate social groups)	2.31	2	.30

TABLE XIII

EFFECTS OF METHOD OF INSTRUCTION ON PROGRAM CHOICE OF

PHYSICS AND NON-PHYSICS MAJORS. (GROUPS I, II AND III COMBINED

Sub-Hypothesis	Variable	x^2	df	p value
$H_{8.1}$	Teacher versus student demonstrations	.013	1	.90
$H_{8.2}$	Note-taking	1.53	3	.70
$H_{8.3}$	Laboratory work	9.72	1	.001
$H_{8.4}$	Class discussions	1.68	2	.50
$H_{8.5}$	Assignments	.04	2	.98
$H_{8.6}$	Projects	.14	2	.70
$H_{8.7}$	Testing	.11	1	.70
$H_{8.8}$	Laboratory reports	1.18	1	.30

TABLE XIV

EFFECT OF MISCELLANEOUS FACTORS ON PROGRAM CHOICE OF PHYSICS AND NON-PHYSICS MAJORS. (GROUPS I, II AND III COMBINED

Sub-Hypothesis	Variable	x^2	df	p value
$H_{9.1}$	Attendance at a high school in a community of population less than 2,500; in a town of population over 2,500; in a city	1.4	2	.20
$H_{9.2}$	Preference of the student to work alone or with a group	2.02	1	.20
$H_{9.3}$	Preference of a student to participate in individual or team sports	2.1	1	.20

In Group II, which represented second year students, no significant differences between physics and non-physics students was detected, even though this group is about equal in numbers to Group I. It may be argued that Group II, at the time the questionnaire was given, was near the end of their second year in university and recall of the academic variables, participation in extra-curricular activities and teacher methodology could have been effected by the lapse of time. The two years since their high school graduation could act as a 'screen' in recalling their experiences. If we focus on the results pertaining to Group I, teacher presentation, involvement in science related activities and literary inclinations appear to influence students to enroll in a physics program. There is general agreement here with reports by Koelsche (1965), Pennington (1960), Simono (1965), Edgerton (1966) and Strauss (1957).

The combined group (Groups I, II and III) indicated a significant difference between physics students and non-physics students in their preference for independent laboratory work ($H_{8.3}$). This appears to agree with studies by Roe (1952), whose groups of scientists reported a developing interest in science when allowed the freedom of the laboratory without teacher direction. Since Group III cannot be termed as being of the same population as Groups I and II, due to the passage of time, the possible changes in attitude to science in the span of years from 1967 to 1969, and other societal factors. The significance of difference between physics and non-physics students in their preference for independent laboratory work should be considered only as a 'tendency', lacking statistically firm backing.

No school or community group or agency affected the student's

decision to enroll in physics any more than they had an affect on the non-physics student in his choice of program. However, there were indications of strong influences by these groups and agencies on both types of students. All responses numbered one under each of the Groups A, B, C, D and E were tabulated and are given in per cent for those students who replied to these influence groups. (Table XV).

Of the School Personnel (Group A), the teacher was highly influential in both physics and non-physics students' career choices, being 86 per cent and 74 per cent respectively. Out-of-School Institutions (Group B), which familiarized students with career fields and published career information were reported by both physics and non-physics students as being influential in their program decision (69 per cent and 66 per cent respectively). Two factors in Community Influences (Group C) were deemed quite important: community activities and pre-university employment (50 per cent and 41 per cent for the physics students and 45 per cent and 46 per cent for the non-physics students respectively). Of the factors which could be classified as Media (Group D), reading about careers influenced both physics and non-physics students (79 per cent and 80 per cent respectively) to a much greater degree than club or radio and television, or participation in science clubs and fairs. Of the Immediate Social Groups (Group E), only persons in the field seemed to have a substantial influence on career decisions (50 per cent and 42 per cent for physics and non-physics students respectively).

The questionnaire attempted to determine the effect of some aspects of personality. Roe (1952), Shannon (1947), Blake (1965) and Terman (1955) reported that scientists and students with high science

TABLE XV

RANKING OF INFLUENCE ON CAREER CHOICE BY PHYSICS AND NON-PHYSICS STUDENTS* (IN PER CENT)

INFLUENCE		PER CENT	
		PHYSICS STUDENTS	NON-PHYSICS STUDENTS
Group A:	School Personnel		
	Subject Teacher	86%	74%
	Principal	5%	5%
	School Counsellor	10%	20%
Group B:	Out of School Institutions		
	University Counselling Services	11%	19%
	School Career Nights	18%	20%
	Published Career Information	69%	66%
Group C:	Community Influences		
	Religious Influence	9%	11%
	Community Activities	50%	45%
	Pre-University Employment	41%	46%
Group D:	Media		
	Radio - TV Media	7%	13%
	Readings	79%	80%
	Participation in Clubs and Fairs	13%	6%
Group E:	Immediate Social Groups		
	Parents	25%	32%
	Friends	29%	20%
	Relatives	4%	9%
	Persons in the Field	50%	42%

* Only the number one rankings are included.

interests were generally 'loners', not well adjusted socially and if not actually anti-social, at least non-social. The present study found no significant differences between students enrolled in a physics program as compared to those not in a physics program in such extra-curricular activities as holding office in a school or community organization, participating in sports, performing arts, or indicating any preference toward individual or group work or sports. This lack of discernible psychological differences is also reported by Strauss (1957) in his study of 89 Ph. D's in physics.

Pennington (1960), Strauss (1962) and Rainwater (1962) reported a positive effect of city residence on science interest. Cole (1956), on the other hand, suggested that cities may in fact deter science talent. The present study could not detect any significant differences between cities, towns of over 2,500 population and towns of under 2,500 population, in relative influence on career choice of students enrolled in the university.

The decision of a science or non-science career was made more often during the student's high school years (39.4 per cent of physics students and 59.6 per cent of non-physics students. (Table XVI) Physics students appeared to be less firm in their decision, or postponed an absolute decision to a later time, as 34.8 per cent reported the decision as a temporary one compared to 15 per cent of the non-physics group.

In response to the query, "Why did you not enroll in a physics program?" (which was answered only by the non-physics students), 27.7 per cent indicated a disinterest in physics and 21.3 per cent showed a lack of knowledge about the physics program (Table XVII). As Vineyard

TABLE XVI

TIME OF PROGRAM DECISION *

TIME OF DECISION	PHYSICS STUDENT		NON-PHYSICS STUDENT	
	Number n=43	Per Cent	Number n=233	Per Cent
At University Registration	3	6.9%	22	9.4%
High School	17	39.5%	139	59.6%
Junior High School	3	6.9%	25	10.7%
Decision a temporary one	15	34.8%	35	15.0%
Other	5	11.6%	12	5.2%

* Only the number one rankings are included.

TABLE XVII

REASONS FOR NOT ENTERING PHYSICS *

		NUMBER	PER CENT
A.	Not interested in physics.	65	27.7%
B.	Do not care for mathematical and laboratory work.	12	5.1%
C.	Did not know enough about the physics program.	50	21.3%
D.	Heard it was difficult.	9	3.8%
E.	Aptitude tests indicated non-science.	5	2.1%
F.	Too specialized.	16	6.8%
G.	Not capable.	23	9.8%
H.	Other.	55	23.4%
	TOTAL	235	100%

* Only the number one rankings are included.

(1959) suggests, there is room for 'evangelism' in teaching of physics. The most common reply to the query, "Why did you enroll in a physics program?", (which was answered by physics students), interest in science was given by 61.7 per cent (Table XVIII).

The response most frequently given to question 21: "From the list of factors given, rank each according to the degree of influence to your choice of university program", was 'interest in the field' by both physics and non-physics students.

TABLE XVIII

REASONS FOR ENTERING PHYSICS*

		NUMBER	PER CENT
A.	Always interested in science.	29	61.7%
B.	I like the precise thinking.	6	12.7%
C.	My hobbies have been science oriented.	0	0.0%
D.	I always wanted to be a scientist.	0	0.0%
E.	I like solving problems of scientific nature.	3	6.3%
F.	I have taken part in science fairs.	1	2.1%
H.	Reading in science subjects.	3	6.3%
I.	Tinkered with science equipment.	1	2.1%
J.	Other.	2	4.2%
	TOTAL	47	100%

* Only the number one rankings are included.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Introduction

In this chapter a brief summary of the research and its findings are presented and recommendations for further research are suggested.

Summary of the Study

In this study an attempt was made to determine some factors which influence a student's choice of career at the university level. More specifically, it focusses on the factors which influence a student to enroll in a physics program. Available literature is not clear-cut in determining characteristics by which one would recognize the potential scientist. A comparison of published studies show opposing results.

Several hypotheses were tested in this research to ascertain what factors influence a student's decision to enroll in a physics program. The data were collected by means of a questionnaire based on a large number of factors which were deemed to have an influence on career choice. The questionnaire was administered to three groups of students, each entering the university in a different year. Each group was divided into a physics and non-physics sub-group.

Only for one of the groups were any factors identified to have a significant effect on choosing a physics program at the university; these are:

1. Stimulating presentation of material by physics teacher.
2. Student involvement in science related activities or hobbies.
3. Literary activities, including reading as a common form of leisure time activity.

In addition, for the three groups combined two other factors

seem to have an effect on enrollment in a physics program at university: high interest in physics and unstructured laboratory experiences.

The size of the community in which a student attends high school does not appear to have any significant effect on his career choice. Communities of under 2,500 population, towns of over 2,500 population and cities appear to contribute a proportionate share of students who enroll in physics at the university level.

From the point of view of the physics teacher, the findings may have certain implications. It appears that the physics student prefers an unstructured form of laboratory investigation and disdains the highly structured laboratory experiences. Perhaps the 'posing' of a problem, with adequate reference material on hand, may be sufficient to encourage a student-initiated investigation. This is consonant with the interest of physics-oriented students who like to be involved in science activities and hobbies, which are usually open-ended. Perhaps equally important is the need for the physics teacher to continually examine the presentation of material in terms of such aspects as enthusiasm, ingenuity, variety, etc.

The study also shows that several groups within the school and community have some impact on career choices for both physics and non-physics students. Of particular importance is the degree of teacher influence reported by both sub-groups. Since a large number (21 per cent) of the students reported little knowledge of the possible careers in physics, the physics teacher obviously must practice a degree of "evangelism" in this regard in the high school.

Recommendations for Further Research

1. This study should be repeated including the longtitudinal aspect, with larger sample size and a more comprehensive questionnaire to yield more reliable conclusions.

2. Since the interest generated by the teacher in the presentation of physics material seems to influence a student's decision to pursue studies in university physics, a more detailed analysis of this teaching needs to be done in terms of teaching methods used, attitudes developed through class activities and personal encouragement of the student to remain in physics and pursue its further study.

3. There seems to be a correlation between vocational opportunities in physics and physics enrollments. A study should be made of the societal factors (economic, ideological, etc) which have an impact on enrollments.

4. A valid method of inventorying student interests should be developed for use by teachers to enable them to identify students with strong science interests at a relatively early age so that they can be better guided and stimulated to pursue their physics interest.

BIBLIOGRAPHY

BIBLIOGRAPHY

ACKROYD, Q. O., ROBERTS, W. G. A Study of Post-School Occupation of Students Who Graduated With University Matriculation From Alberta High Schools in 1949. Masters Thesis. University of Alberta. 1952.

ASTIN, Helen S. Patterns of Career Choices Over Time. Personnel and Guidance Journal 45: No 6, 1967.

BACHELORS SURVEY SHOWS MOVEMENT OUT OF PHYSICS. Physics Today. 26: No 6, June 1973.

BLAKE, V. An Application of Social-Psychological Theory in the Choice of a Scientific Career. Ph. D. Thesis. University of Alberta. 1965.

BONDI, Professor H. International Conference on Physics Education. Edinburgh, Scotland, 1975

BROWNLEY, D. Allan. Physics in Perspective. Physics Today 25: No. 7 July 1972.

COLE, Charles C. Jr. Encouraging Scientific Talent. College Entrance Examination Board. New York, 1956.

DAVIS, James A. Undergraduate Career Decisions. Aldine Publishing Co. Chicago, 1965.

DeLORA, Dr. J., HARDER, Dr. D. F., KIDWELL, Dr. W. M. Status Images-Their Nature and Relation to Selection of College Majors and Occupations. Study College Placement Council. San Diego State College Foundation. Oct. 1964.

DIETRICH, Don. Grading Practices of High School Physics Teachers: A Contribution to Declining Enrollments in Physics. Science Education 57: 1973.

EDGERTON, H. A. Science Talent: It's Early Identification and Later Development. Journal of Experimental Education 34: pp.90-96, 1966.

EIDUSON, B. T. Scientists: Their Psychological World. Basic Books Inc. New York, 1962.

ELLIS, Susanne. Bachelor's Survey Shows Movement Out of Physics. Physics Today 25: pp. 6. June, 1973.

EMPTY SEATS AT EDINBURGH. Times Educational Supplement. Dec. 1964.

FLANAGAN, J. C. The American High School Student. Pittsburgh, University of Pittsburgh, Project Talent Office, 1964.

GROPPER, G. L., FITZPATRICK, R. Who Goes to Graduate School: A Study of the Decisions to Enter Graduate Training. Master Thesis. University of Alberta, 1959.

KLUFAS, H. Teacher Characteristics - Physics 30 Achievement. Masters Thesis. University of Alberta, 1964.

KNOWLES, Donald. The Influence of Faculty High School Size and Sex In the Prediction of Freshman Success Using Departmental and Principal's Rating Grade XII Scores. Master Thesis. University of Alberta, 1964.

KOELSCHE, Charles L. Characteristics of Potential Scientist. Science Education 1: University of Georgia. Feb, 1965.

NICHOLS, R. C. Career Decisions of Very Able Students. Science. June, 1964.

PENNINGTON, T.S. A Study of Factors Which Affected High School Seniors Interested in Science. Masters Thesis. Florida State University, 1960.

PHYSICS, EDUCATION AND SOCIETY. Physics Education 10: Nov. 1975.

PREPARING HIGH SCHOOL PHYSICS TEACHERS. Commission of College Physics. University of Maryland. 1962.

REITZ, J. G. The Flight From Science Reconsidered: Career Choice of Science and Engineering in the 50's and 60's. Science Education. 57: pp. 121-134, 1973.

ROE, Anne. A Psychological Study of Emminent Biologists. Psychological Monographs 65: 1951.

ROE, Anne. The Making of a Scientist. Dodd, Mead & Co., New York, 1952.

SCIENCE EDUCATION. Science News 106: No. 10, pp. 145-160. Sept. 7, 1974.

SHANNON, J. R. Traits of Research Workers. Journal of Educational Research 40: pp. 513-21, 1947.

SIEGAL, S. Nonparametric Statistics for Behavioral Sciences. McGraw-Hill Book Company. New York, Toronto, Canada, 1956.

SIMONO, R. B. The Prediction of Science and Non-Science Undergraduate Majors Among a Group of Male High School Students. Ph. D. Thesis. University of Wisconsin. 1965.

SNELLING, W. Rodman, BORUCH, Robert. Factors Influencing Student Choice of College and Course of Study. Journal of Chemical Education 47: pp. 326. May, 1970.

STRANBERG, L. A. Teacher Characteristics and Science Achievement. Masters Thesis. University of Alberta, 1966.

STRAUSS, A. L. RAINWATER, L. The Professional Scientist: A Study of American Chemists. Aldine Publishing Co. Chicago, 1962.

STRAUSS, S. Looking Backward on Future Scientists. Science Teacher 24: pp. 385-88, 1957.

TERMAN, L. M. Scientists and Non-Scientists in a Group of 800 Gifted Men. Psychological Monographs 68: pp. 1-44, 1954.

TERMAN, L. M. Are Scientists Different. Scientific American 192: pp. 25-29, 1955.

VINEYARD, E. E. An Independent Study of Choice of Science and Non-Science Majors as Related to Ability and Interest Test Scores. Science Education 43: 1959.

VLASSIS, Constantine G. Future Scientists: Whose Responsibility? Science Education 1: 49, Feb. 1965.

WALBERG, H. J. Dimension of Scientific Interests in Boys and Girls Studying Physics. (Harvard University). Science Education 51: #2, pp. 111-116. Mar. 1967.

WALLACH, Meralee. GraduateB.S. in Physics Seeking Graduate Work In Other Fields. Physics Today. 25: No. 3. March, 1972.

WYNN, D. C., BLEDSOE, J.C. Factors Related to Gain and Loss of Scientific Interests During High School. Science Education 51: pp. 67-74, 1967.

APPENDICES

APPENDIX "A"

QUESTIONNAIRE

DIRECTIONS: Where you are asked to rank items, use 1 as the highest 2 as the next highest, and so on.

UNIVERSITY PROGRAM INFORMATION

1. In what faculty are you presently enrolled? ________________
2. In what program are you presently enrolled? ________________
   (Elec. Eng., Hon, Math., Gen. Chem, etc.) ________________
3. In what year of your program are you presently working? ______
4. Towards what degree are you presently working? ____________

HIGH SCHOOL HISTORY

5. Indicate where each of your High School grades was taken:

	GRADE 10	GRADE 11	GRADE 12
a. In a city	______	______	______
b. In a town of over 2,500 population	______	______	______
c. In a town of under 2,500 population	______	______	______

6. Rank the following subjects in order of the highest mark you achieved to the lowest marks achieved in the subjects throughout high school.
   Exclude any subjects not taken.

English	______
Social Studies	______
Mathematics	______
Physics	______
Chemistry	______
Biology	______
Foreign Language	______

7. Rank the following High School subjects from the one you found most interesting to the least interesting. Exclude any subject not taken.

English ______

Social Studies ______

Mathematics ______

Physics ______

Chemistry ______

Biology ______

Foreign Language ______

8. Rank the High School subjects listed in order from the one which you found most challenging to least challenging. Exclude any subject not taken.

English ______

Social Studies ______

Mathematics ______

Physics ______

Biology ______

Foreign Language ______

9. Rank your teachers in each subject below as to their knowledge of the subject. Exclude any subject not taken.

English ______

Social Studies ______

Mathematics ______

Physics ______

Chemistry ______

Biology ______

Foreign Language ______

10. Rank the subjects below in which you feel you consistently work the hardest in terms of: assignments, homework, reading, etc. Exclude any subject not taken.

English ______

Social Studies ______

Mathematics ______

Physics ______

Chemistry ______

Biology ______

Foreign Language ______

11. Rank your subject teachers in the subjects below according to interesting and stimulating presentation of subject matter. Exclude any subject not taken.

English ______

Social Studies ______

Mathematics ______

Physics ______

Chemistry ______

Biology ______

Foreign Language ______

12. Below are listed a group of teaching methods used by teachers. Rank each member of each group according to the frequency used by your high school Science teachers, your Physics teacher, and on the far right column, the method you prefer as a student.

METHODS	SCIENCE TEACHERS	PHYSICS TEACHERS	PREFERRED BY YOU
a. Demonstrations	______	______	______
- by pupil	______	______	______
- by teacher	______	______	______
b. Notes on the course			
- taken from lecture	______	______	______
- making own notes	______	______	______
- relying on text	______	______	______
- blackboard summaries	______	______	______
c. Laboratory work by students			
- directed by teacher or manual	______	______	______
- independent	______	______	______
d. Class discussions			
- drill and taking up assignments	______	______	______
- open discussions between teacher and pupils	______	______	______
- reading of prepared reports followed by discussion	______	______	______
e. Assignments			
- reading text-book	______	______	______
- reading supplementary references	______	______	______
- questions and mathematics problems	______	______	______
f. Projects			
- individual	______	______	______

METHODS	SCIENCE TEACHERS	PHYSICS TEACHERS	PREFERRED BY YOU
- group	______	______	______
- class	______	______	______
g. Testing			
- frequent short tests unannounced	______	______	______
- frequent short tests announced	______	______	______
h. Laboratory Reports			
- formal write-ups	______	______	______
- informal write-ups	______	______	______

13. List the high school organizations to which you belong.

(Student Union Executive, Drama, Red Cross, etc.)

______________________ ______________________

______________________ ______________________

______________________ ______________________

14. Did you ever enter a school science fair? ______________________

15. Did you ever enter a regional science fair? ______________________

16. List the hobbies or activities you engaged in during your leisure time.

(Reading, skiing, music, mechanics, etc.)

______________________ ______________________

______________________ ______________________

______________________ ______________________

17. List the community activities in which you participated during your high school years. (Drama groups, choir, scouts, etc.)

______________________ ______________________

18. Do you usually like to work with a group or do you prefer to work alone?____

19. Do you prefer team sports or individual sports?________________

CAREER CHOICE INCLUENCES

20. Rank the items IN EACH of the following groups according to the degree of influence each may have had on your university program selection.

DO ALL GROUPS

GROUP A:

a. Subject teachers ______

b. Principal ______

c. School Counsellor ______

GROUP B:

a. University counselling service ______

b. School Career nights ______

c. Published career information ______

GROUP C:

a. Religious influence ______

b. Community activities ______

c. Pre-university employment ______

GROUP D:

a. Radio - TV media ______

b. Readings ______

c. Participation in clubs and fairs______

GROUP E:

a. Parents ______

b. Friends ______

c. Relatives ______

d. Persons in the field ______

21. From the list of factors given below, rank each according to the degree of influence to your choice of university program. (Select only those that apply to you).

a. Future employment prospects are promising. ______

b. Positions in the field are highly paid. ______

c. The program has prestige. ______

d. Your friends were entering the same program ______

e. Parental pressure. ______

f. Pressure from relatives ______

g. Other(Specify) ______

22. From the following list regarding the time you made your choice of program, select the one which applies to you.

a. Your decision was made at the time of registration at university ______

b. Your choice of program was made in high school ______

c. Your choice of program was made in junior high school ______

d. The University program is a temporary one. You have made no firm decisions as yet ______

e. Other (Specify) ______

23. If you are NOT enrolled in either the general or Honours Physics program, select those reasons for not enrolling in such a program. Rank them in order of importance.

a. I was never strongly interested in physics. ______

b. I do not care for subjects involving mathematics, laboratory work, etc. ______

c. I did not know enough about the nature of a Physics program, its length, employment opportunities, etc., at the time of university registration ______

d. I heard it was a difficult program with a high failure rate. ______

e. Aptitude tests and interest inventory tests indicated a non science career. ______

f. A physics program is too specialized at the under-graduate level.

g. I do not think I am capable of completing such a program ______

h. Other (Specify)______________________________ ______

24. If you ARE enrolled in the general Physics or Honours Physics program, select and rank those factors which influenced your decision to enter such a program.

a. I was always interested in science. ______

b. I like the precise thinking characterized by science. ______

c. My hobbies have been science-oriented ______

d. I have always wanted to be a scientist ______

e. I like solving problems of a scientific nature. ______

f. I have taken part in school Science Fairs and have found the work rewarding. ______

g. Aptitude and Interest Tests indicated a science career. ______

h. My reading interests in subjects scientific and science biographies predisposed me towards a career in science. ______

i. Throughout my school life, I have tinkered with science equipment in my spare time. ______

j. Other (Specify)______________________________ ______

APPENDIX "B"

SYNOPSIS OF PILOT PROJECT

As stated previously, the purpose of the pilot project was to test the questionnaire for ambiguity, to revise items in order that they may yield pertinent information, and possible revisions in structure. All twenty respondents returned the questionnaire. No statistical treatment of data was attempted other than a nose-count, and indication of trends.

The group was divided into two groups - those registered in the Faculty of Science and Engineering, and those registered in non-science faculties.

Of the total group, fifteen are in Science and Engineering faculties; five are in other faculties. In both groups, the town/city radio was approximately the same. Of the fifteen in the Engineering-Science Group, seven were registered in Engineering, two in General Science, two in Honours Mathematics, two in Honours Physics, and one each in pre-medicine and computing sciences.

SUBJECTS IN WHICH HIGHEST MARKS WERE ACHIEVED

Subjects in which highest marks were achieved:

	Engineering-Science Group	Non-Science Group
	Mathematics-Science	Mathematics-Science
Lowest marks:		
	English-Social Studies	Foreign Language-Social Studies
Most Interesting Subject:		
	Mathematics	Social Studies

Engineering Science Group	Non-Science Group
Least Interesting Subject:	
English-Foreign Language	Foreign Language
Most Challenging:	
Physics	Physics
Least Challenging:	
English	English-Mathematics

Teacher Rating In Subject Found Most Interesting (Total Group):

Excellent	11
Good	9
Fair	0
Poor	0
Very Poor	0

Teacher Rating Of Subject Found Less Interesting (Total Group):

Excellent	3
Good	8
Fair	6
Poor	2
Very Poor	1

Teaching Method Used By Science Teachers:

Both Groups were taught by expository mode.

(Both Honours Physics students reported more than adequate laboratory facilities, and use of A-V aids).

Time Program Choice Was Made:

Junior High School	4
High School	7
At Registration	4

Reason For Choosing Program:

Interest area
Employment opportunity
High paid positions

APPENDIX "C"

CHI-SQUARE CONTINGENCY TABLES H_1 TO H_9

H_1: For Group I of the experimental population there will be no significant difference between students who did enroll in a physics program as compared with students who did not, for each of the following academic reasons:

$H_{1.1}$: Marks achieved in physics.

	High Marks	Low Marks	
Physics	24	1	25
Non-Physics	80	12	92
	104	13	117

chi-square=0.84 df=1 p=0.36

$H_{1.2}$: Interest expressed by student in physics.

	High Interest	Low Interest	
Physics	22	3	25
Non-Physics	67	25	92
	87	28	117

chi-square=2.48 df=1 p=.11

$H_{1.3}$: Student's perception of challenge in physics.

	High Challenge	Low Challenge	
Physics	16	9	25
Non-Physics	61	31	92
	77	40	117

chi-square=.05 df=1 p=.83

$H_{1.4}$: Student's perception of teacher's knowledge of physics:

	High Knowledge	Low Knowledge	
Physics	13	12	25
Non-Physics	43	49	92
	56	61	117

chi-square=0.27 df=1 p=.64

$H_{1.5}$: Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.

	High Work Effort	Low Work Effort	
Physics	9	16	25
Non-Physics	47	45	92
	56	61	117

chi-square=1.79 df=1 p=.18

$H_{1.6}$: Interest generated by teacher in the presentation of physics.

	High Stimulation	Low Stimulation	
Physics	18	7	25
Non-Physics	41	51	92
	59	58	117

chi-square=5.92 df=1 p=0.015

H_2: For Group II of the experimental population there will be no significant difference between students who did enroll in a physics program as compared with students who did not, for each of the following academic factors:

$H_{2.1}$: Marks achieved in physics.

	High Marks	Low Marks	
Physics	11	1	12
Non-Physics	71	9	80
	82	10	92

chi-square=.04 df=1 p=.85

$H_{2.2}$: Interest expressed by student in physics.

	High Interest	Low Interest	
Physics	11	1	12
Non-Physics	56	24	80
	67	25	92

chi-square=1.50 df=1 p=.22

$H_{2.3}$: Student's perception of challenge in physics.

	High Challenge	Low Challenge	
Physics	6	2	12
Non-Physics	61	19	80
	67	25	92

chi-square=2.43 df=1 p=.12

$H_{2.4}$: Student's perception of teacher's knowledge of physics.

	High Knowledge	Low Knowledge	
Physics	9	3	12
Non-Physics	42	38	80
	51	41	92

chi-square=2.14 df=1 p=.14

$H_{2.5}$: Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.

	High Effort	Low Effort	
Physics	7	5	12
Non-Physics	46	34	80
	53	39	92

chi-square=.00 df=1 p=.96

$H_{2.6}$: Interest generated by teacher in the presentation of physics.

	High Stimulation	Low Stimulation	
Physics	8	4	12
Non-Physics	40	40	80
	48	44	92

chi-square=1.16 df=1 p=.28

H_3: For Group III of the experimental population there will be no significant difference between students who did enroll in a physics program as compared with students who did not, for each of the following academic factors:

$H_{3.1}$: Marks achieved in physics.

	High Marks	Low Marks	
Physics	4	2	6
Non-Physics	32	27	59
	36	29	65

chi-square=.02 df=1 p=.88

$H_{3.2}$: Interest expressed by student in physics.

	High Interest	Low Interest	
Physics	5	1	6
Non-Physics	31	28	59
	36	29	65

chi-square=1.03 df=1 p=.31

$H_{3.3}$: Student's perception of challenge in physics.

	High Challenge	Low Challenge	
Physics	33	3	6
Non-Physics	39	20	59
	42	23	65

chi-square=.11 df=1 p=.74

$H_{3.4}$: Student's perception of teacher's knowledge of physics.

	High Knowledge	Low Knowledge	
Physics	4	2	6
Non-Physics	22	37	59
	26	39	65

chi-square=.93 df=1 p=.34

$H_{3.5}$: Degree of effort the student put into the study of physics in terms of homework, assignments, readings, etc.

	High Effort	Low Effort	
Physics	4	2	6
Non-Physics	21	38	59
	25	60	65

chi-square=1.10 df=1 p=.29

$H_{3.6}$: Interest generated by teacher in the presentation of physics.

	High Stimulation	Low Stimulation	
Physics	4	2	6
Non-Physics	23	36	59
	27	38	65

chi-square=.77 df=1 p=.38

H_4: For Group I of the experimental population there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for involvement in the following extra-curricular activities:

$H_{4.1}$: Executive and committee positions.

	Involvement	Non-Involvement	
Physics	8	17	25
Non-Physics	35	57	92
	43	77	117

chi-square=.31 df=1 p=.58

$H_{4.2}$: Sports.

	Involvement	Non-Involvement	
Physics	13	12	25
Non-Physics	73	19	92
	86	31	117

chi-square=7.55 df=1 p=.006

$H_{4.3}$: Science Activities.

	Involvement	Non-Involvement	
Physics	14	11	25
Non-Physics	18	74	42
	32	85	117

chi-square=13.13 df=1 p=.003

$H_{4.4}$: Fine arts.

	Involvement	Non-Involvement	
Physics	9	23	25
Non-Physics	35	57	92
	44	73	117

chi-square=.035 df=1 p=.85

$H_{4.5}$: Arts and crafts.

	Involvement	Non-Involvement	
Physics	2	23	25
Non-Physics	5	87	92
	7	110	117

chi-square=.000 df=1 p=.99

$H_{4.6}$: Literary activities.

	Involvement	Non-Involvement	
Physics	17	8	25
Non-Physics	37	55	92
	54	63	117

chi-square=6.12 df=1 p=.013

$H_{4.7}$: Speaking and debating.

	Involvement	Non-Involvement	
Physics	2	23	25
Non-Physics	5	87	92
	7	110	117

chi-square=.000 df=1 p=.99

$H_{4.8}$: Service clubs.

	Involvement	Non-Involvement	
Physics	6	19	25
Non-Physics	22	70	92
	28	89	117

chi-square=.000 df=1 p=.99

$H_{4.9}$: Other club activities.

	Involvement	Non-Involvement	
Physics	8	17	25
Non-Physics	31	61	92
	39	78	117

chi-square=.025 df=1 p=.87

H_5: For Group II of the experimental population there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for involvement in the following extra-curricular activities:

$H_{5.1}$: Executive and committee positions.

	Involvement	Non-Involvement	
Physics	5	7	12
Non-Physics	34	46	80
	39	53	92

chi-square=.003 df=1 p=.96

$H_{5.2}$: Sports.

	Involvement	Non-Involvement	
Physics	8	4	12
Non-Physics	56	24	80
	64	28	92

chi-square=.01 df=1 p=.91

$H_{5.3}$: Science activities.

	Involvement	Non-Involvement	
Physics	5	7	12
Non-Physics	18	62	80
	23	69	92

chi-square=1.15 df=1 p=.28

$H_{5.4}$: Fine arts.

	Involvement	Non-Involvement	
Physics	1	11	12
Non-Physics	24	56	80
	25	67	92

chi-square=1.50 df=1 p=.22

$H_{5.5}$: Arts and crafts.

	Involvement	Non-Involvement	
Physics	3	9	12
Non-Physics	13	67	80
	16	76	92

chi-square=.11 df=1 p=.74

$H_{5.6}$: Literary activities.

	Involvement	Non-Involvement	
Physics	7	5	12
Non-Physics	37	43	80
	44	48	92

chi-square=.61 df=1 p=.43

$H_{5.7}$: Speaking and debating.

	Involvement	Non-Involvement	
Physics	0	12	12
Non-Physics	4	76	80
	4	88	92

chi-square=.001 df=1 p=.97

$H_{5.8}$: Service clubs.

	Involvement	Non-Involvement	
Physics	1	11	12
Non-Physics	14	66	80
	15	77	92

chi-square=.15 df=1 p=.70

$H_{5.9}$: Other club activities.

	Involvement	Non-Involvement	
Physics	3	9	12
Non-Physics	26	54	80
	29	63	92

chi-square=.035 df=1 p=.85

H_6: For Group III of the experimental population there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for involvement in the following extra-curricular activities.

$H_{6.1}$: Executive and committee positions.

	Involvement	Non-Involvement	
Physics	3	3	6
Non-Physics	32	27	59
	35	30	65

chi-square=.054 df=1 p=.82

$H_{6.2}$: Sports.

	Involvement	Non-Involvement	
Physics	6	0	6
Non-Physics	45	14	59
	51	14	65

chi-square=.68 df=1 p=.41

$H_{6.3}$: Science activities.

	Involvement	Non-Involvement	
Physics	0	6	6
Non-Physics	13	46	59
	13	52	65

chi-square=.56 df=1 p=.45

$H_{6.4}$: Fine arts.

	Involvement	Non-Involvement	
Physics	5	1	6
Non-Physics	28	31	59
	33	32	65

chi-square=1.55 df=1 p=.21

$H_{6.5}$: Arts and crafts.

	Involvement	Non-Involvement	
Physics	0	6	6
Non-Physics	12	47	59
	12	53	65

chi-square=.45 df=1 p=.50

$H_{6.6}$: Literary activities.

	Involvement	Non-Involvement	
Physics	3	3	6
Non-Physics	25	34	59
	28	37	65

chi-square=.005 df=1 p=.94

$H_{6.7}$: Speaking and debating.

	Involvement	Non-Involvement	
Physics	1	5	6
Non-Physics	3	56	59
	4	61	65

chi-square=.054 df=1 p=.82

$H_{6.8}$: Service clubs.

	Involvement	Non-Involvement	
Physics	2	4	6
Non-Physics	9	50	59
	11	54	65

chi-square=.31 df=1 p=.58

$H_{6.9}$: Other club activities.

	Involvement	Non-Involvement	
Physics	3	3	6
Non-Physics	21	38	59
	24	41	65

chi-square=.064 df=1 p=.80

H_7: For the entire experimental population (Groups I, II and III combined), there will be no significant difference between students who did enroll in a physics program as compared to those who did not for each of the following influence groups.

$H_{7.1}$: Group A. (School personnel)

	Teacher	Principal	Counsellor	
Physics	(33.4) 37	(2.2) 2	(7.3) 4	43
Non-Physics	(162.5) 159	(10.8) 11	(35.7) 39	209
	196	13	43	252

chi-square=2.29 df=2 p=.30

$H_{7.2}$: Group B. (Out of school institutions)

	University Counselling Service	School Career Nights	Published Career Information	
Physics	(6.2) 4	(6.8) 7	(25) 27	38
Non-Physics	(34.8) 37	(38.4) 38	(25) 140	215
	41	45	167	253

chi-square=1.12 df=2 p=.50

$H_{7.3}$: Group C. (Community Influences)

	Religious Influences	Community Activities	Pre-University Employment	
Physics	(3.3) 3	(14.5) 16	(14.2) 13	32
Non-Physics	(19.7) 20	(86.5) 85	(84.8) 86	191
	23	101	99	223

chi-square=.34 df=2 p=.80

$H_{7.4}$: Group D. (Media)

	Radio and T.V. Media	Readings	Participation In Clubs	
Physics	(4.7) 3	(33.6) 33	(2.7) 5	41
Non-Physics	(25.3) 27	(178) 179	(14.3) 12	218
	30	212	17	259

chi-square=3.14 df=2 p=.20

$H_{7.5}$: Group E. (Immediate social group)

	Parents	Friends	Relatives	Person in the Field	
Physics	(11.9) 9	(8.2) 11	(3) 1	(16.8) 19	40
Non-Physics	(65.1) 68	(44.8) 42	(16.9) 19	(92.2) 90	219
	77	53	20	109	259

chi-square=2.31 df=3 p=.30

H_8: For the entire experimental population (Groups I, II and III combined), there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for each of the following preferred method of instruction in physics:

$H_{8.1}$: Teacher versus student demonstrations.

	Teacher Demonstration	Student Demonstration	
Physics	29	14	43
Non-Physics	156	77	233
	185	91	276

chi-square=.013 df=1 p=.90

$H_{8.2}$: Note-taking.

	Taken from Lecture	Making Own Notes	Text	Blackboard Summaries	
Physics	(15.4) 19	(6.3) 6	(16) 15	(12.2) 10	50
Non-Physics	(87.5) 84	(35.7) 36	(91) 92	(68.8) 71	283
	103	42	107	81	333

chi-square= 1.53 df=3 p=.70

$H_{8.3}$: Laboratory work.

	Teacher-Manual Directed	Independent	
Physics	18	23	41
Non-Physics	152	72	224
	170	95	265

chi-square=9.72 df=1 p=.001

$H_{8.4}$: Class discussions.

	Drill and Assignments	Open Discussion Teacher Pupil	Reading of Prepared Reports and Discussion	
Physics	(13.9) 12	(24.9) 25	(3.1) 5	42
Non-Physics	(75) 77	(134) 134	(16.9) 15	226
	89	159	20	268

chi-square=1.68 df=2 p=.50

$H_{8.5}$: Assignments.

	Reading Text-book	Reading Supplementary References	Questions and Mathematical Problems	
Physics	(7.2) 7	(4.3) 4	(29.6) 30	41
Non-Physics	(39.8) 40	(23.7) 24	(164.6) 164	228
	47	28	194	269

chi-square=.04 df=2 p=.98

$H_{8.6}$: Projects.

	Individual	Group	Class	
Physics	(21.6) 22	(.15) 15	(1.4) 1	38
Non-Physics	(116.4) 116	(80.9) 81	(7.6) 8	205
	138	96	9	243

chi-square=.14 df=2 p=.70

$H_{8.7}$: Testing.

	Frequent Short Tests Unannounced	Frequent Short Tests Announced	
Physics	8	35	43
Non-Physics	43	179	222
	51	214	265

chi-square=.11 df=1 p=.70

$H_{8.8}$: Laboratory Reports.

	Formal Write-ups	Informal Write-ups	
Physics	18	23	41
Non-Physics	74	146	220
	92	169	261

chi-square=1.18 df=1 p=.30

H_9: For the entire experimental population (Groups I, II and III combined), there will be no significant difference between students who did enroll in a physics program as compared to those who did not, for the following miscellaneous factors:

$H_{9.1}$: Attendance at a high school in a community of population less than 2,500, in a town of population over 2,500, in a city.

	City	Town over 2,500	Community less than 2,500	
Physics	(29.9) 33	(6.2) 4	(5.9) 5	42
Non - Physics	(162) 159	(33.8) 36	(32) 33	228
	192	40	38	270

chi-square=1.4 df=1 p=.20

$H_{9.2}$: Preference of the student to work alone or with a group.

	Group	Alone	
Physics	10	29	39
Non - Physics	79	141	226
	89	170	259

chi-square=2.02 df=1 p=.20

$H_{9.3}$: Preference of a student to participate in individual or team sports.

	Individual	Team	
Physics	23	14	37
Non - Physics	106	103	209
	117	106	246

chi-square=2.1 df=1 p=.20

APPENDIX "D"

CHI-SQUARE STATISTICAL TABLES

TABLE C. TABLE OF CRITICAL VALUES OF CHI SQUARE*

df	Probability under H_0 that $\chi^2 \geq$ chi square													
	.99	.98	.95	.90	.80	.70	.50	.30	.20	.10	.05	.02	.01	.001
1	.00016	.00063	.0039	.016	.064	.15	.46	1.07	1.64	2.71	3.84	5.41	6.64	10.83
2	.02	.04	.10	.21	.45	.71	1.39	2.41	3.22	4.60	5.99	7.82	9.21	13.82
3	.12	.18	.35	.58	1.00	1.42	2.37	3.66	4.64	6.25	7.82	9.84	11.34	16.27
4	.30	.43	.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	11.67	13.28	18.46
5	.55	.75	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	13.39	15.09	20.52
6	.87	1.13	1.64	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	15.03	16.81	22.46
7	1.24	1.56	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	16.62	18.48	24.32
8	1.65	2.03	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	18.17	20.09	26.12
9	2.09	2.53	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	19.68	21.67	27.88
10	2.56	3.06	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	21.16	23.21	29.59
11	3.05	3.61	4.58	5.58	6.99	8.15	10.34	12.90	14.63	17.28	19.68	22.62	24.72	31.26
12	3.57	4.18	5.23	6.30	7.81	9.03	11.34	14.01	15.81	18.55	21.03	24.05	26.22	32.91
13	4.11	4.76	5.39	7.04	8.63	9.93	12.34	15.12	16.98	19.81	22.36	25.47	27.69	34.53
14	4.66	5.37	6.57	7.79	9.47	10.82	13.34	16.22	18.15	21.06	23.68	26.87	29.14	36.12
15	5.23	5.98	7.26	8.55	10.31	11.72	14.34	17.32	19.31	22.31	25.00	28.26	30.58	37.70
16	5.81	6.61	7.96	9.31	11.15	12.62	15.34	18.42	20.46	23.54	26.30	29.63	32.00	39.29
17	6.41	7.26	8.67	10.08	12.00	13.53	16.34	19.51	21.62	24.77	27.59	31.00	33.41	40.75
18	7.02	7.91	9.39	10.86	12.86	14.44	17.34	20.60	22.76	25.99	28.87	32.35	34.80	42.31
19	7.63	8.57	10.12	11.65	13.72	15.35	18.34	21.69	23.90	27.20	30.14	33.69	36.19	43.82
20	8.26	9.24	10.85	12.44	14.58	16.27	19.34	22.78	25.04	28.41	31.41	35.02	37.57	45.32
21	8.90	9.92	11.59	13.24	15.44	17.18	20.34	23.86	26.17	29.62	32.67	36.34	38.93	46.80
22	9.54	10.60	12.34	14.04	16.31	18.10	21.24	24.94	27.30	30.81	33.92	37.66	40.29	48.27
23	10.20	11.29	13.09	14.85	17.19	19.02	22.34	26.02	28.43	32.01	35.17	38.97	41.64	49.73
24	10.86	11.99	13.85	15.66	18.06	19.94	23.34	27.10	29.55	33.20	36.42	40.27	42.98	51.18
25	11.52	12.70	14.61	16.47	18.94	20.87	24.34	28.17	30.68	34.38	37.65	41.57	44.31	52.62
26	12.20	13.41	15.38	17.29	19.82	21.79	25.34	29.25	31.80	35.56	38.88	42.86	45.64	54.05
27	12.88	14.12	16.15	18.11	20.70	22.72	26.34	30.32	32.91	36.74	40.11	44.14	46.96	55.48
28	13.56	14.85	16.93	18.94	21.59	23.65	27.34	31.39	34.03	37.92	41.34	45.42	48.28	56.89
29	14.26	15.57	17.71	19.77	22.48	24.58	28.34	32.46	35.14	39.09	42.56	46.69	49.59	58.30
30	14.95	16.31	18.49	20.60	23.36	25.51	29.34	33.53	36.25	40.26	43.77	47.96	50.89	59.70

* Table C is abridged from Table IV of Fisher and Yates: *Statistical tables for biological, agricultural, and medical research*, published by Oliver and Boyd Ltd., Edinburgh, by permission of the authors and publishers.